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Tran et al.

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[54] EMBEDDED MISSION AVIONICS DATA LINK SYSTEM

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[51] Int. Cl.[6] G08B 21/00

[52] U.S. Cl. 340/945; 340/961; 340/971; 340/990; 340/995; 340/963; 701/208

[58] Field of Search 340/990, 995, 340/945, 967, 971, 963; 701/208, 14, 301, 3; 342/13, 15, 16, 17

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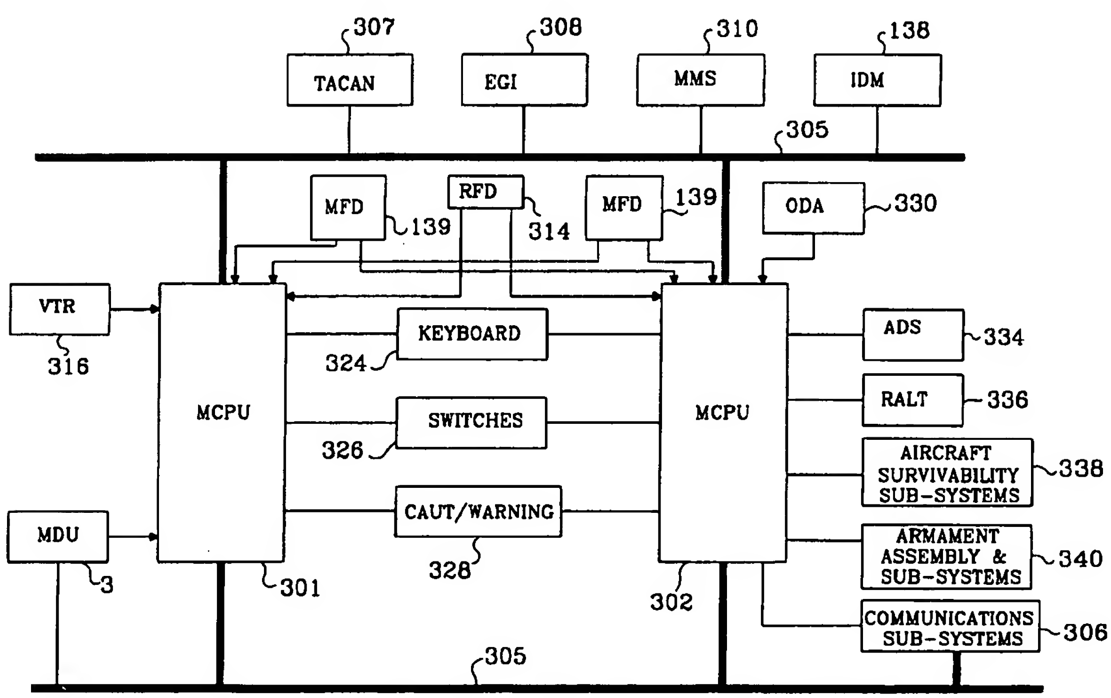
Attorney, Agent, or Firm—Andrew A. Abeyta; Kenneth J. Johnson

[57] ABSTRACT

An embedded mission avionics data link system is provided which allows an aircraft to receive, transmit, and process a variety of different types of information. The present system has the capability of generating and receiving video information for viewing by a pilot in the cockpit. The system also requests, receives and recognizes situation awareness data as well as mission update data and processes this information accordingly. Any video images received by the pilot either externally or internally may be annotated and either stored in memory or transmitted externally. The system allows multiple aircraft on a mission to stay in constant communication as to relative positions to each other and targets, provide up-to-date information as to the situation which exists at the target, and do this in a mostly automatic fashion which reduces the workload of the pilot and significantly enhance the mission capability.

32 Claims, 13 Drawing Sheets



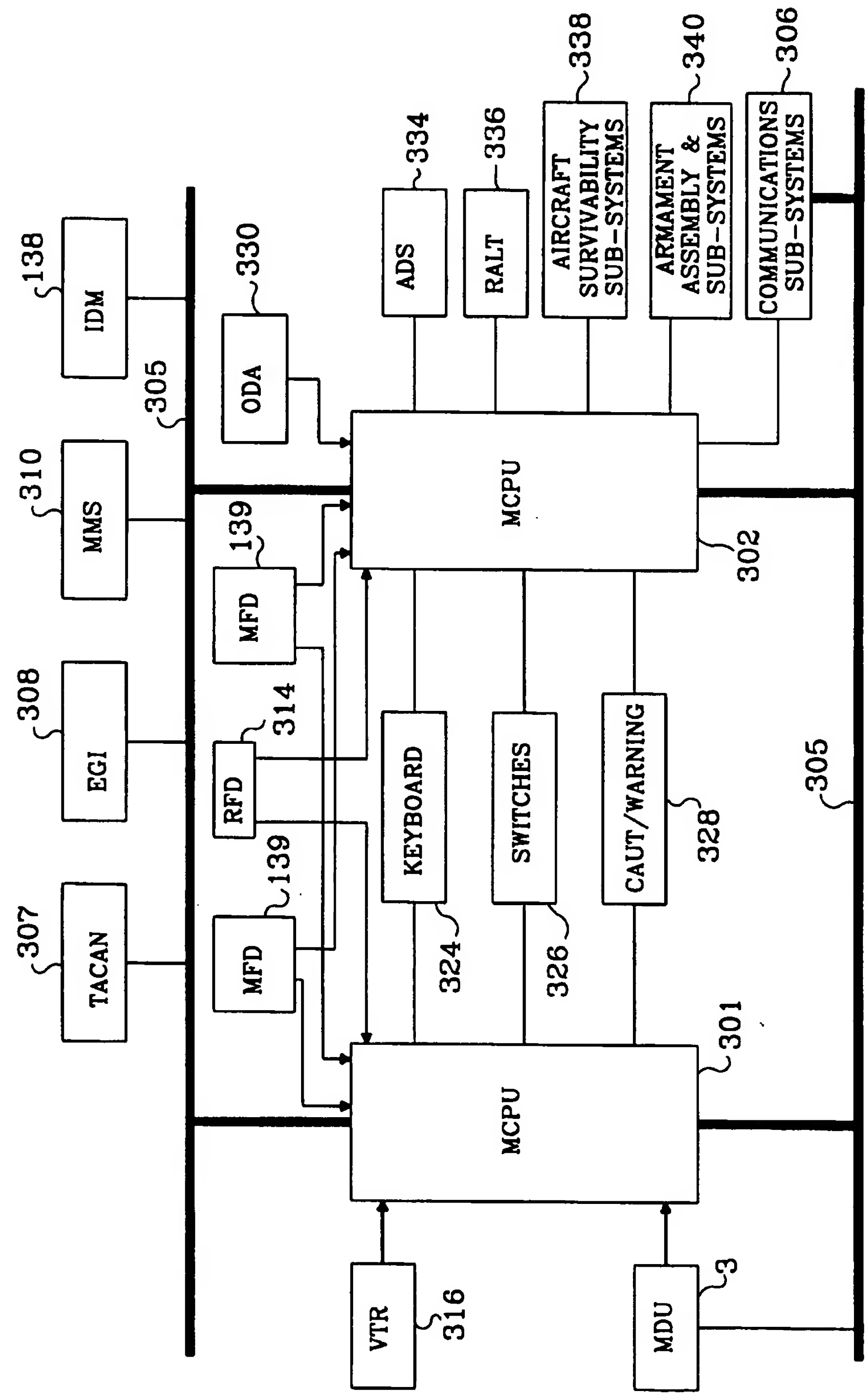

IDM
138
MMS
310
EGI
308
TACAN
307
305
ODA
330
MFD
139
RFD
314
MFD
139
ADS
334
RALT
336
AIRCRAFT SURVIVABILITY SUB-SYSTEMS
338
ARMAMENT ASSEMBLY & SUB-SYSTEMS
340
COMMUNICATIONS SUB-SYSTEMS
306
MCPU
302
KEYBOARD
324
SWITCHES
326
CAUT/WARNING
328
305
MCPU
301
VTR
316
MDU
3

Fig. 1

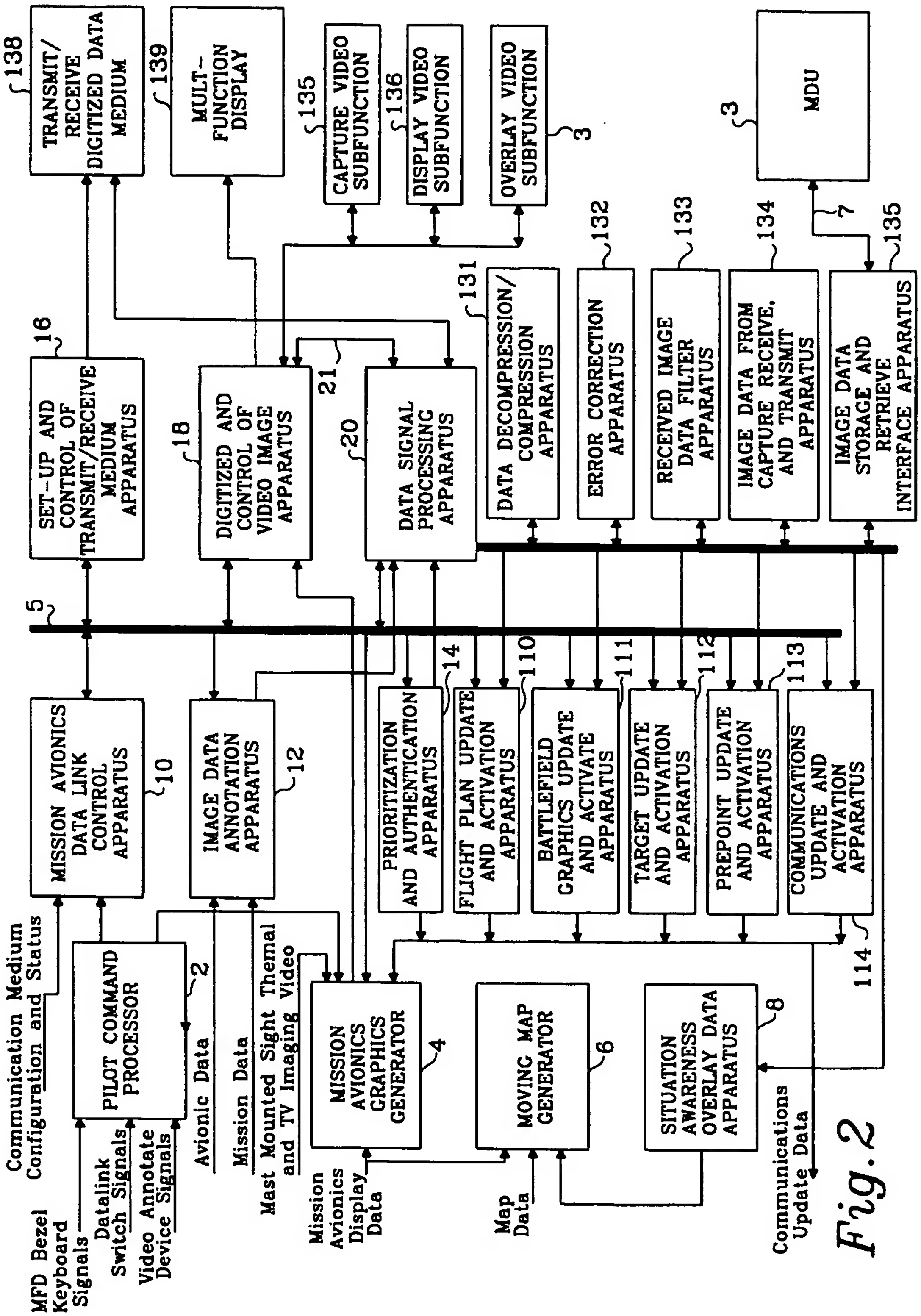

TRANSMIT/ RECEIVE DIGITIZED DATA MEDIUM
138
MULT-FUNCTION DISPLAY
139
CAPTURE VIDEO SUBFUNCTION
135
DISPLAY VIDEO SUBFUNCTION
136
OVERLAY VIDEO SUBFUNCTION
3
MDU
3
7
SET-UP AND CONTROL OF TRANSMIT/RECEIVE MEDIUM APPARATUS
16
DIGITIZED AND CONTROL OF VIDEO IMAGE APPARATUS
18
21
DATA SIGNAL PROCESSING APPARATUS
20
DATA DECOMPRESSION/ COMPRESSION APPARATUS
131
ERROR CORRECTION APPARATUS
132
RECEIVED IMAGE DATA FILTER APPARATUS
133
IMAGE DATA FROM CAPTURE RECEIVE, AND TRANSMIT APPARATUS
134
IMAGE DATA STORAGE AND RETRIEVE INTERFACE APPARATUS
135
5
MISSION AVIONICS DATA LINK CONTROL APPARATUS
10
IMAGE DATA ANNOTATION APPARATUS
12
PRIORITIZATION AND AUTHENTICATION APPARATUS
14
FLIGHT PLAN UPDATE AND ACTIVATION APPARATUS
110
BATTLEFIELD GRAPHICS UPDATE AND ACTIVATE APPARATUS
111
TARGET UPDATE AND ACTIVATION APPARATUS
112
PREPOINT UPDATE AND ACTIVATION APPARATUS
113
COMMUNICATIONS UPDATE AND ACTIVATION APPARATUS
114
Communication Medium Configuration and Status
PILOT COMMAND PROCESSOR
2
MFD Bezel Keyboard Signals
Datalink Switch Signals
Video Annotate Device Signals
Avionic Data
Mission Data
Mast Mounted Sight Themal and TV Imaging Video
MISSION AVIONICS GRAPHICS GENERATOR
4
Mission Avionics Display Data
MOVING MAP GENERATOR
6
Map Data
SITUATION AWARENESS OVERLAY DATA APPARATUS
8
Communications Update Data

Fig. 2

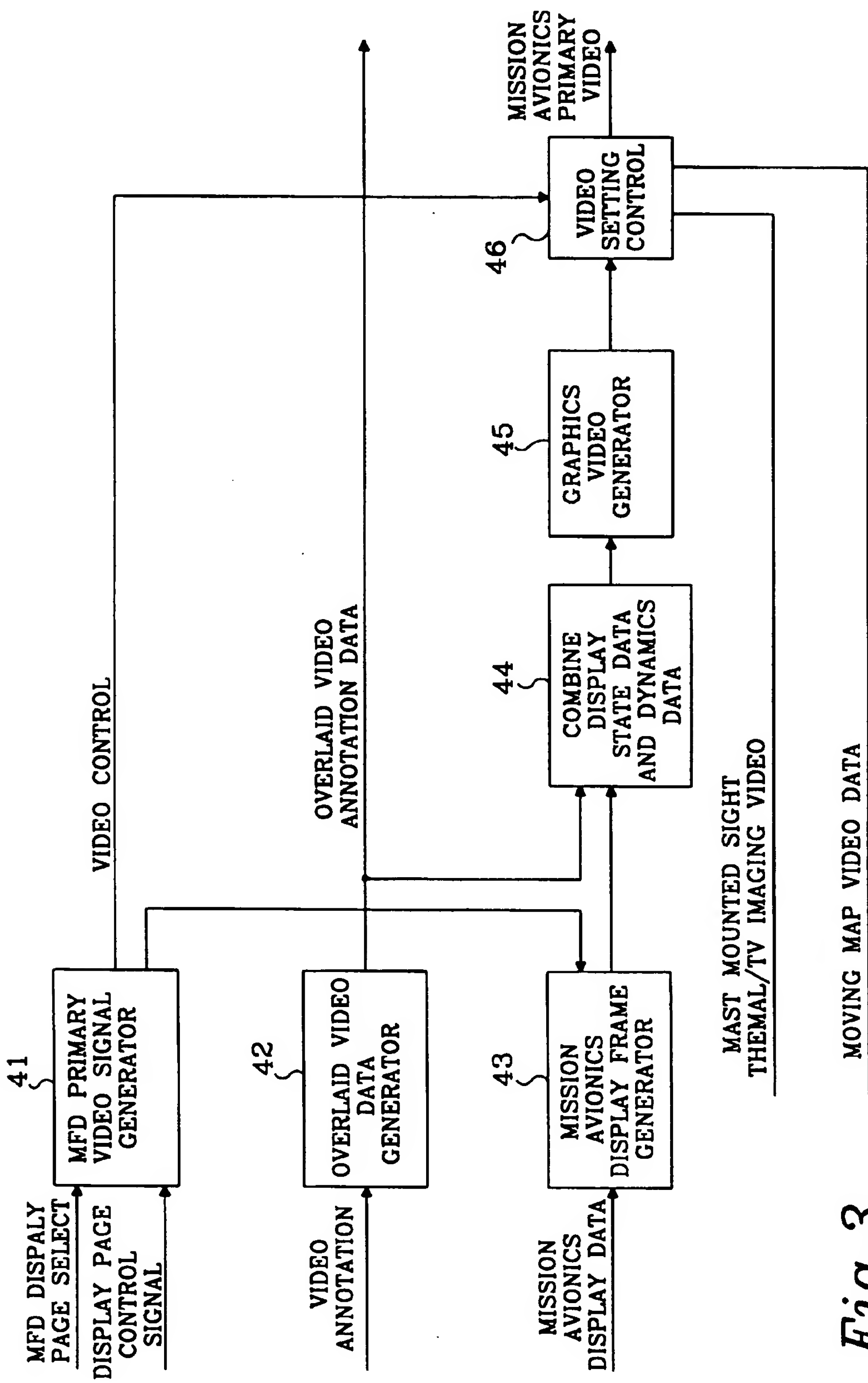

MFD DISPALY PAGE SELECT
DISPLAY PAGE CONTROL SIGNAL
41
MFD PRIMARY VIDEO SIGNAL GENERATOR
VIDEO CONTROL
VIDEO ANNOTATION
42
OVERLAID VIDEO DATA GENERATOR
OVERLAID VIDEO ANNOTATION DATA
MISSION AVIONICS DISPLAY DATA
43
MISSION AVIONICS DISPLAY FRAME GENERATOR
44
COMBINE DISPLAY STATE DATA AND DYNAMICS DATA
45
GRAPHICS VIDEO GENERATOR
46
VIDEO SETTING CONTROL
MISSION AVIONICS PRIMARY VIDEO
MAST MOUNTED SIGHT THEMAL/TV IMAGING VIDEO
MOVING MAP VIDEO DATA

Fig. 3

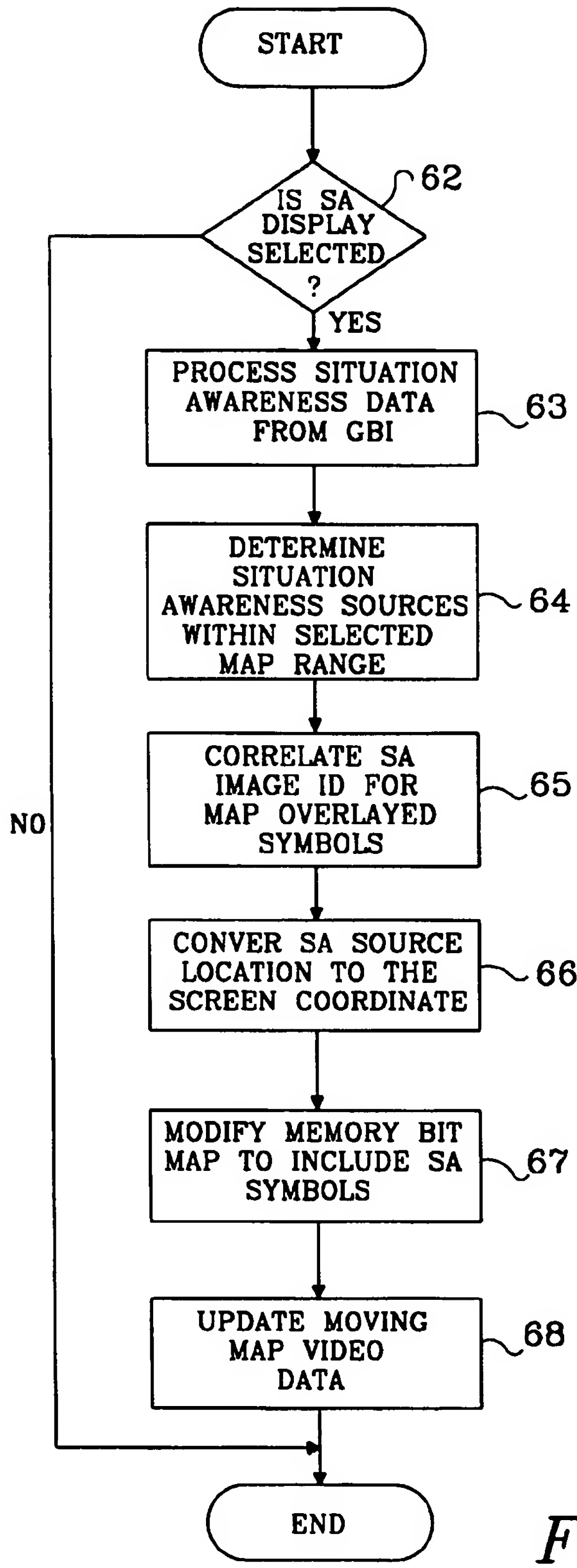

START
IS SA DISPLAY SELECTED ?
62
YES
NO
PROCESS SITUATION AWARENESS DATA FROM GBI
63
DETERMINE SITUATION AWARENESS SOURCES WITHIN SELECTED MAP RANGE
64
CORRELATE SA IMAGE ID FOR MAP OVERLAYED SYMBOLS
65
CONVER SA SOURCE LOCATION TO THE SCREEN COORDINATE
66
MODIFY MEMORY BIT MAP TO INCLUDE SA SYMBOLS
67
UPDATE MOVING MAP VIDEO DATA
68
END

Fig. 4

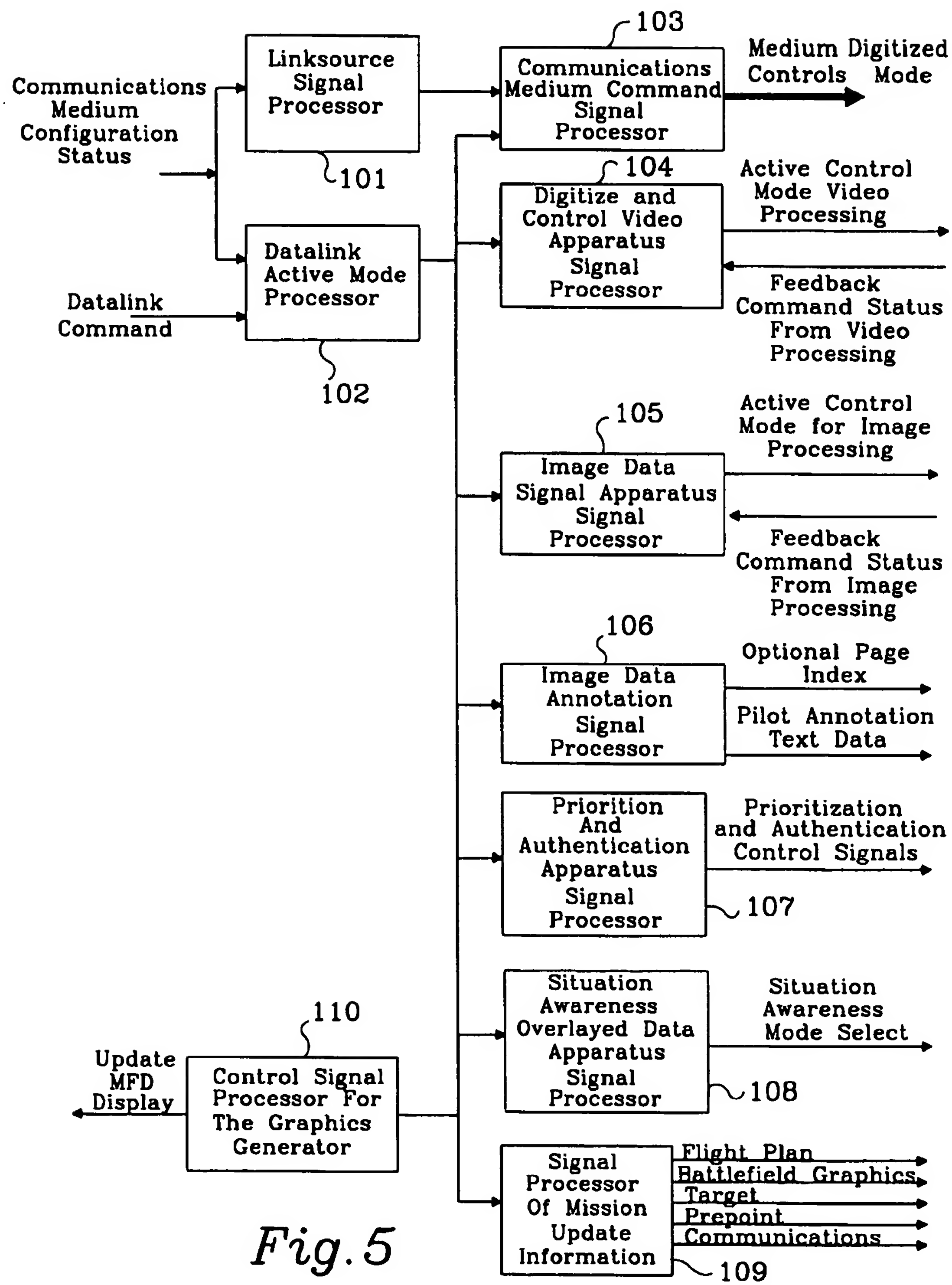

Communications Medium Configuration Status
Linksource Signal Processor
101
Datalink Command
Datalink Active Mode Processor
102
103
Communications Medium Command Signal Processor
Medium Digitized Controls Mode
104
Digitize and Control Video Apparatus Signal Processor
Active Control Mode Video Processing
Feedback Command Status From Video Processing
105
Image Data Signal Apparatus Signal Processor
Active Control Mode for Image Processing
Feedback Command Status From Image Processing
106
Image Data Annotation Signal Processor
Optional Page Index
Pilot Annotation Text Data
Priorition And Authentication Apparatus Signal Processor
Prioritization and Authentication Control Signals
107
Situation Awareness Overlayed Data Apparatus Signal Processor
Situation Awareness Mode Select
108
110
Update MFD Display
Control Signal Processor For The Graphics Generator
Signal Processor Of Mission Update Information
Flight Plan
Battlefield Graphics
Target
Prepoint
Communications
109

Fig. 5

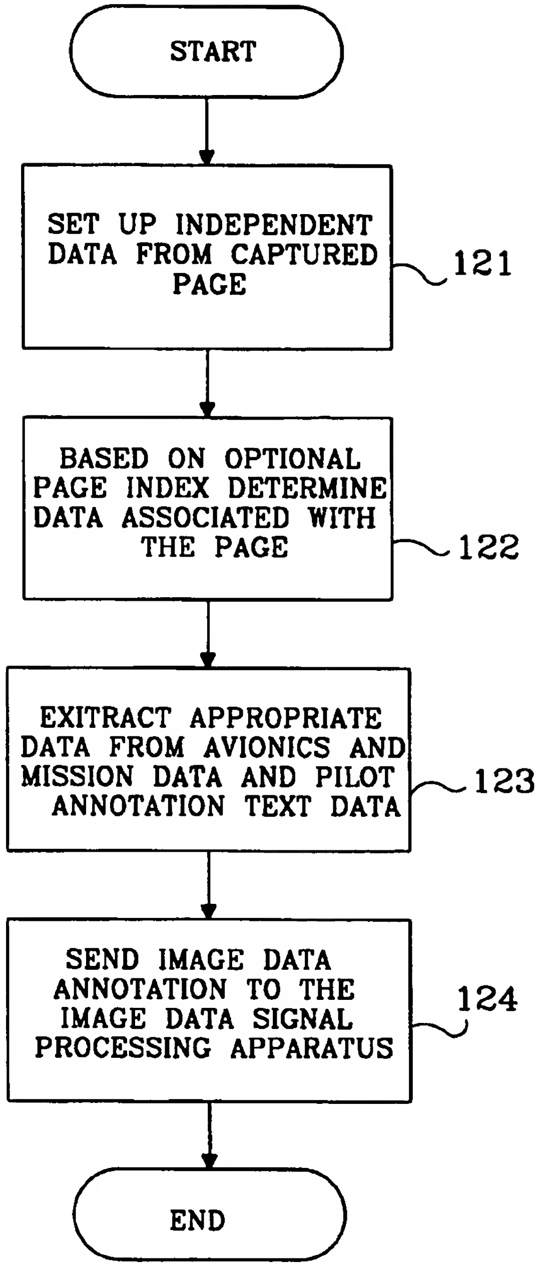

START
SET UP INDEPENDENT DATA FROM CAPTURED PAGE
121
BASED ON OPTIONAL PAGE INDEX DETERMINE DATA ASSOCIATED WITH THE PAGE
122
EXITRACT APPROPRIATE DATA FROM AVIONICS AND MISSION DATA AND PILOT ANNOTATION TEXT DATA
123
SEND IMAGE DATA ANNOTATION TO THE IMAGE DATA SIGNAL PROCESSING APPARATUS
124
END

Fig. 6

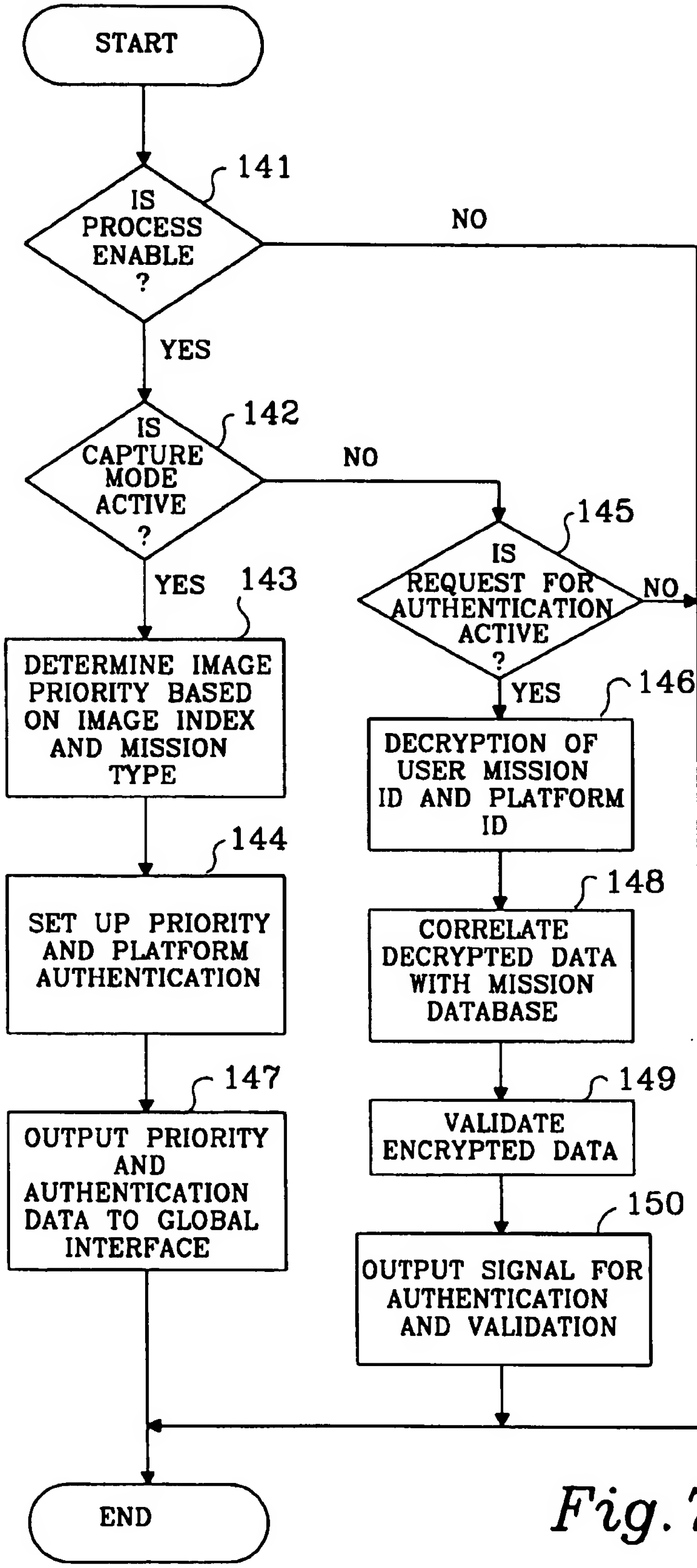

START
141
IS PROCESS ENABLE ?
NO
YES
142
IS CAPTURE MODE ACTIVE ?
NO
145
YES
143
IS REQUEST FOR AUTHENTICATION ACTIVE ?
NO
DETERMINE IMAGE PRIORITY BASED ON IMAGE INDEX AND MISSION TYPE
YES
146
DECRYPTION OF USER MISSION ID AND PLATFORM ID
144
SET UP PRIORITY AND PLATFORM AUTHENTICATION
148
CORRELATE DECRYPTED DATA WITH MISSION DATABASE
147
OUTPUT PRIORITY AND AUTHENTICATION DATA TO GLOBAL INTERFACE
149
VALIDATE ENCRYPTED DATA
150
OUTPUT SIGNAL FOR AUTHENTICATION AND VALIDATION
END

Fig. 7

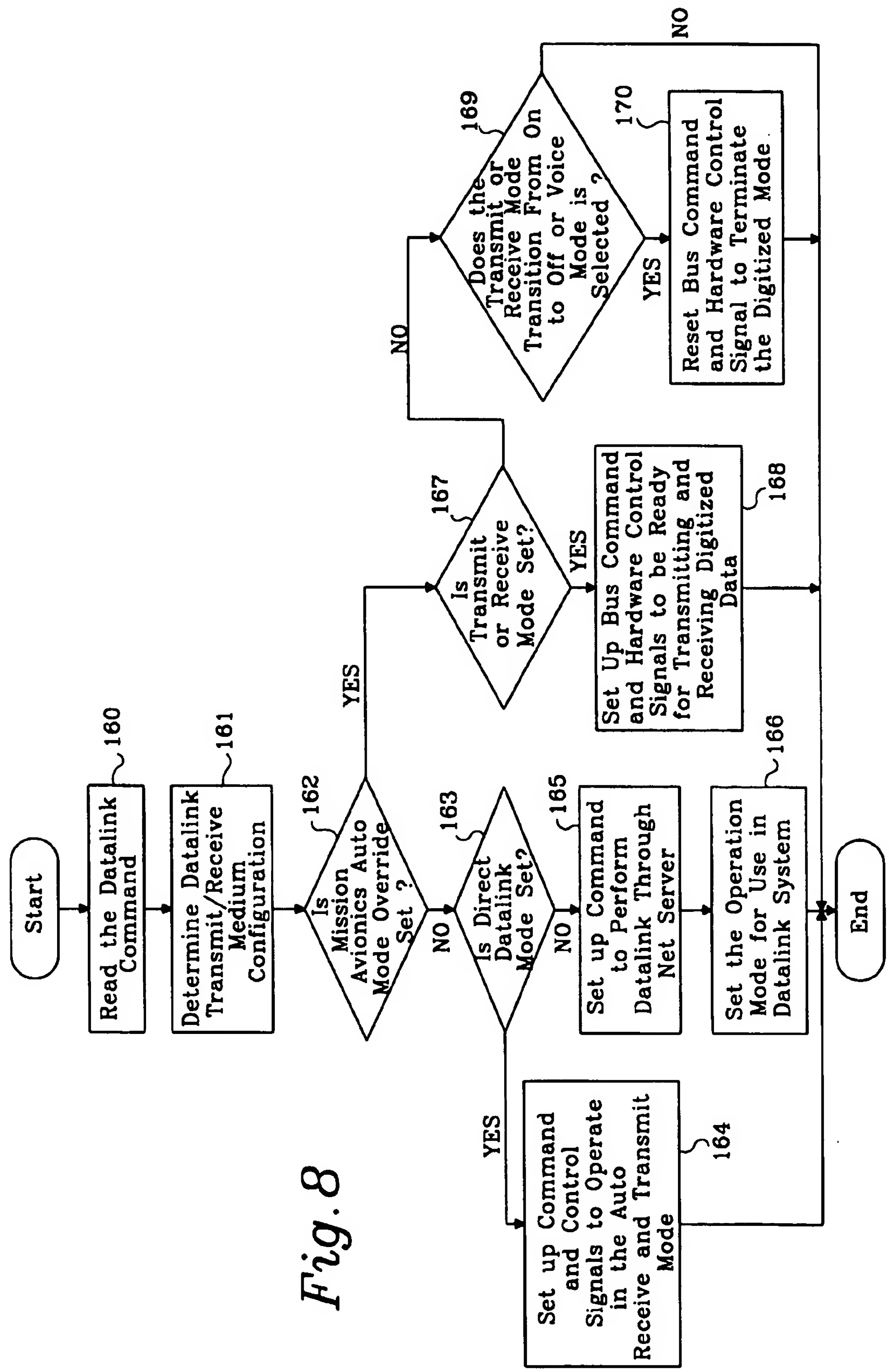

Start
Read the Datalink Command
160
Determine Datalink Transmit/Receive Medium Configuration
161
Is Mission Avionics Auto Mode Override Set ?
162
YES
NO
Is Direct Datalink Mode Set?
163
YES
NO
Set up Command and Control Signals to Operate in the Auto Receive and Transmit Mode
164
Set up Command to Perform Datalink Through Net Server
165
Set the Operation Mode for Use in Datalink System
166
End
Is Transmit or Receive Mode Set?
167
YES
NO
Set Up Bus Command and Hardware Control Signals to be Ready for Transmitting and Receiving Digitized Data
168
Does the Transmit or Receive Mode Transition From On to Off or Voice Mode is Selected ?
169
YES
NO
Reset Bus Command and Hardware Control Signal to Terminate the Digitized Mode
170

Fig. 8

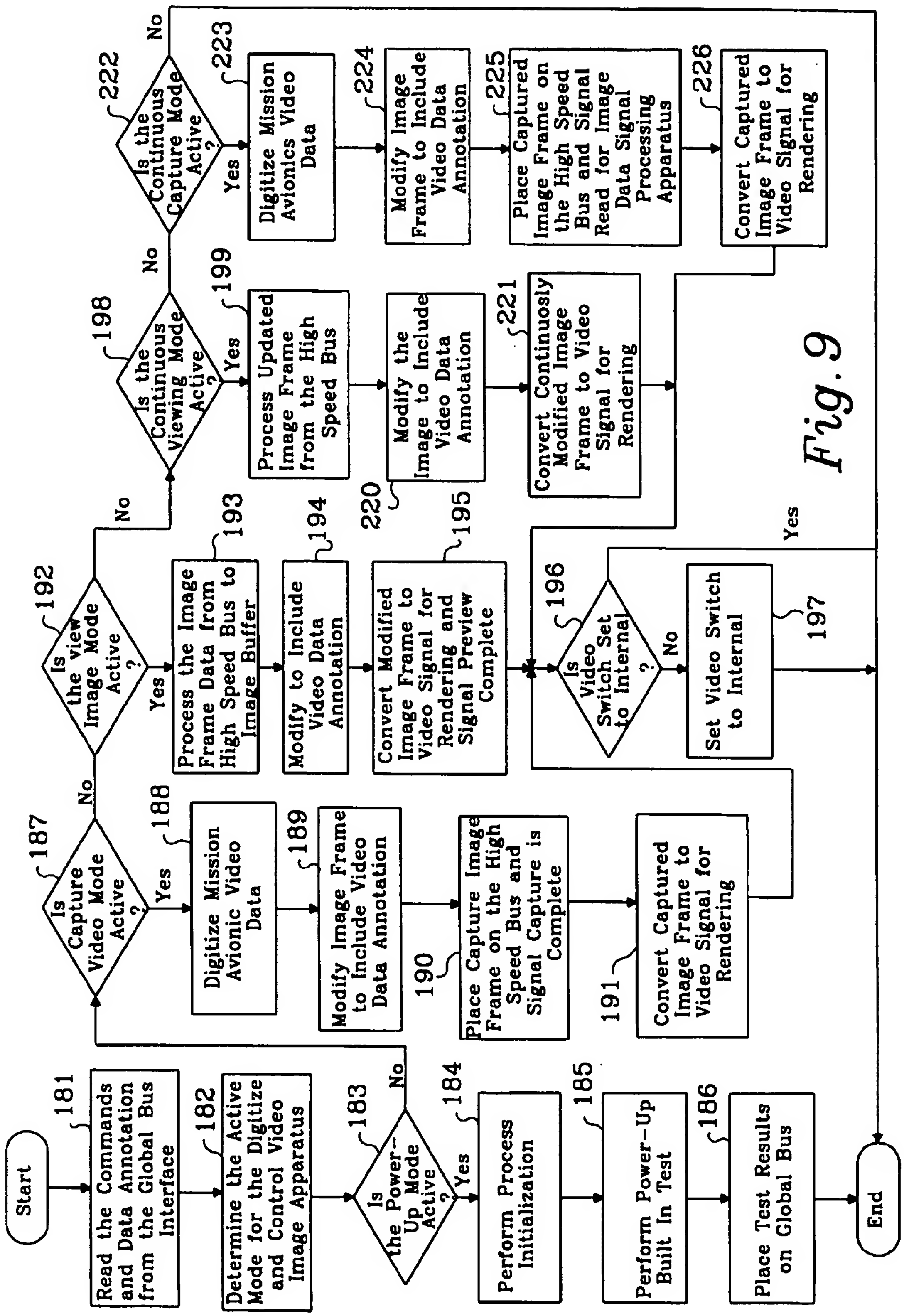

Start
Read the Commands and Data Annotation from the Global Bus Interface
181
Determine the Active Mode for the Digitize and Control Video Image Apparatus
182
Is the Power-Up Mode Active ?
183
Yes
No
Perform Process Initialization
184
Perform Power-Up Built In Test
185
Place Test Results on Global Bus
186
End
Is Capture Video Mode Active ?
187
Yes
No
Digitize Mission Avionic Video Data
188
Modify Image Frame to Include Video Data Annotation
189
Place Capture Image Frame on the High Speed Bus and Signal Capture is Complete
190
Convert Captured Image Frame to Video Signal for Rendering
191
Is the view Image Mode Active ?
192
Yes
No
Process the Image Frame Data from High Speed Bus to Image Buffer
193
Modify to Include Video Data Annotation
194
Convert Modified Image Frame to Video Signal for Rendering and Signal Preview Complete
195
Is Video Switch Set to Internal ?
196
Yes
No
Set Video Switch to Internal
197
Is the Continuous Viewing Mode Active ?
198
Yes
No
Process Updated Image Frame from the High Speed Bus
199
Modify the Image to Include Video Data Annotation
220
Convert Continuosly Modified Image Frame to Video Signal for Rendering
221
Is the Continuous Capture Mode Active ?
222
Yes
No
Digitize Mission Avionics Video Data
223
Modify Image Frame to Include Video Data Annotation
224
Place Captured Image Frame on the High Speed Bus and Signal Read for Image Data Signal Processing Apparatus
225
Convert Captured Image Frame to Video Signal for Rendering
226

Fig. 9

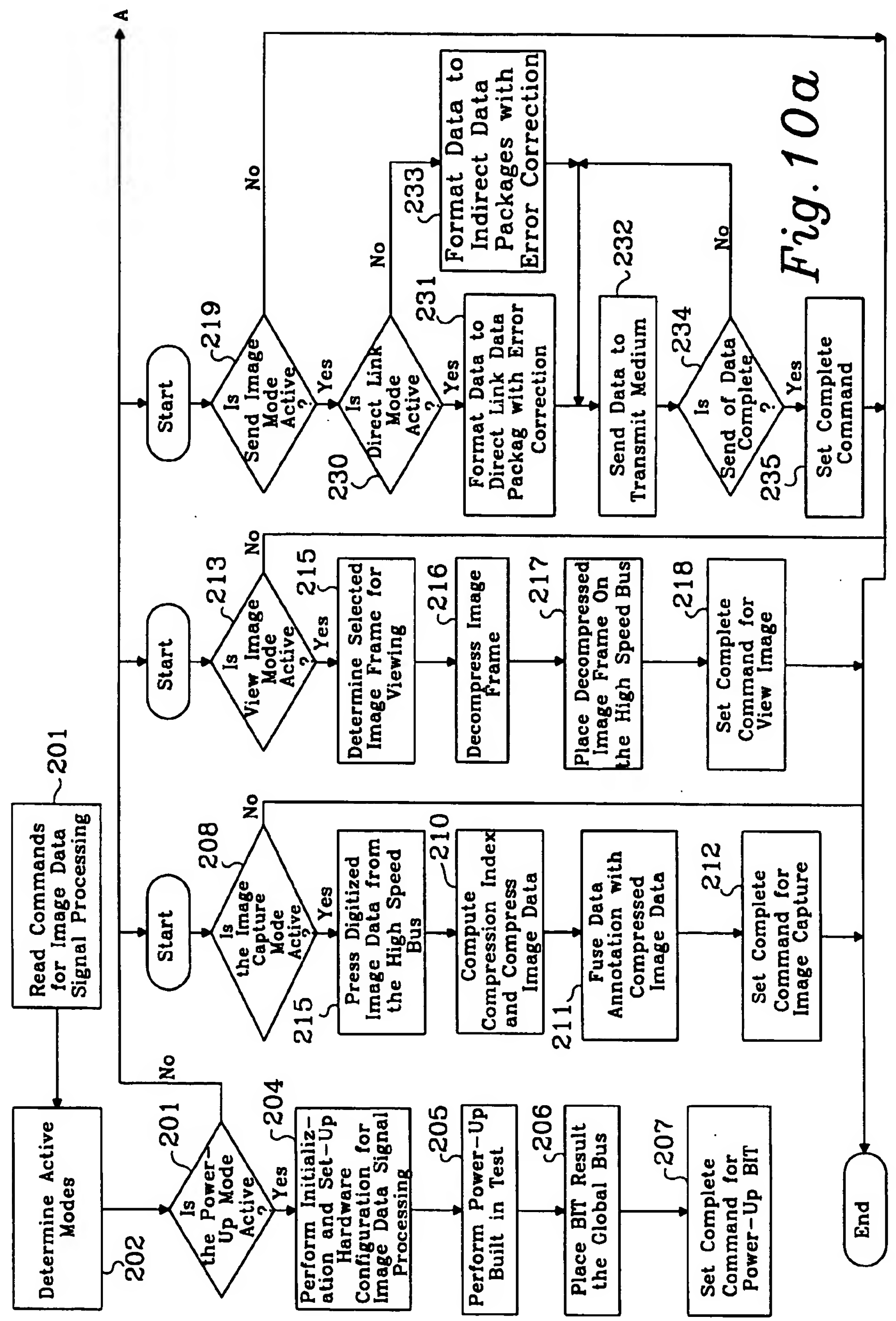

Read Commands for Image Data Signal Processing
201
Determine Active Modes
202
Is the Power-Up Mode Active ?
201
No
Yes
204
Perform Initialization and Set-Up Hardware Configuration for Image Data Signal Processing
205
Perform Power-Up Built in Test
206
Place BIT Result the Global Bus
207
Set Complete Command for Power-Up BIT
End
A
Start
Is the Image Capture Mode Active ?
208
No
Yes
215
Press Digitized Image Data from the High Speed Bus
210
Compute Compression Index and Compress Image Data
211
Fuse Data Annotation with Compressed Image Data
212
Set Comland Command for Image Capture
Start
Is View Image Mode Active ?
213
No
Yes
215
Determine Selected Image Frame for Viewing
216
Decompress Image Frame
217
Place Decompressed Image Frame On the High Speed Bus
218
Set Complete Command for View Image
Start
Is Send Image Mode Active ?
219
No
Yes
Is Direct Link Mode Active ?
230
No
Yes
Format Data to Direct Link Data Packag with Error Correction
231
Format Data to Indirect Data Packages with Error Correction
233
Send Data to Transmit Medium
232
Is Send of Data Complete ?
234
No
Yes
Set Complete Command
235

Fig. 10a

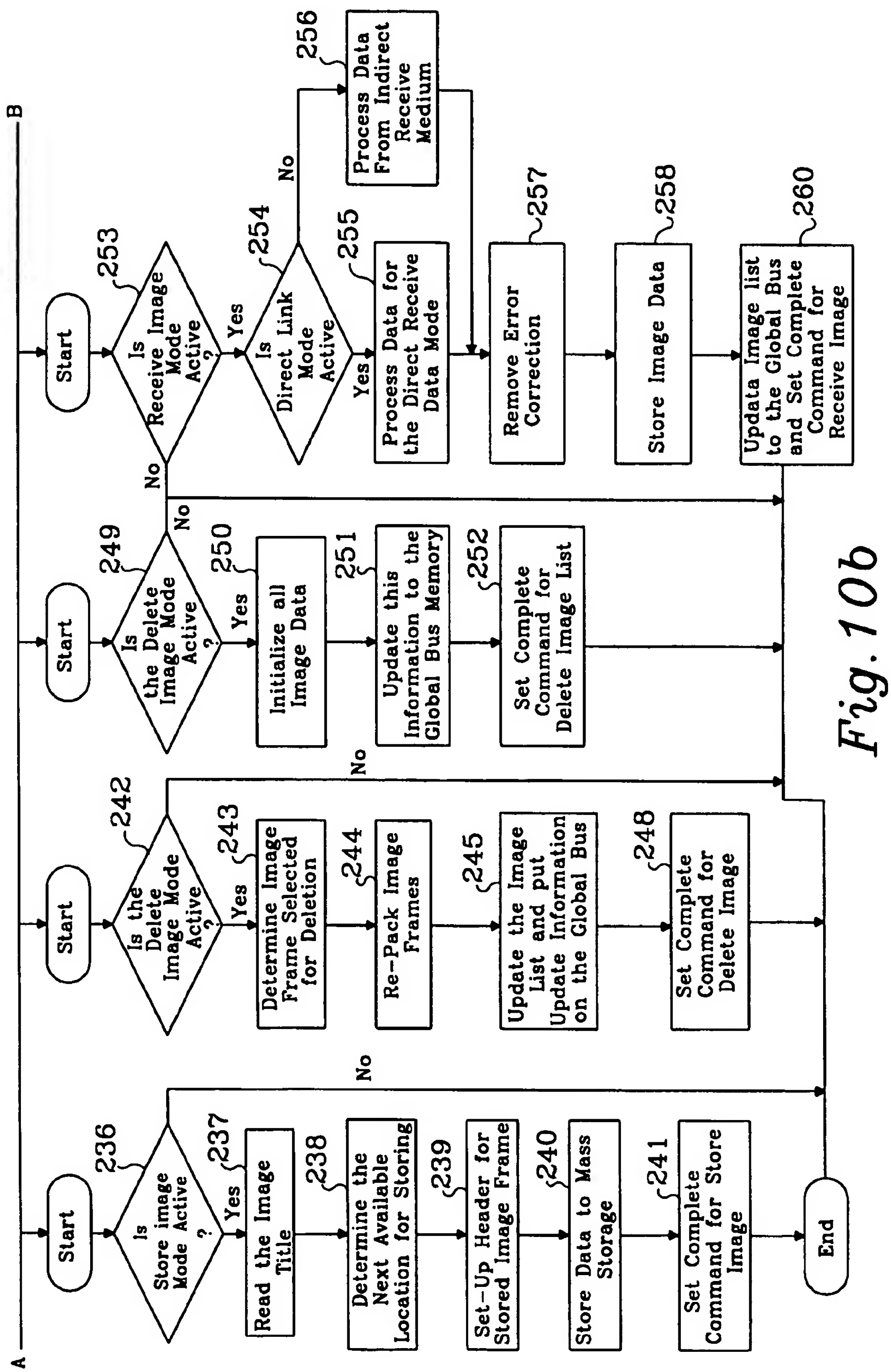

A
B
Start
236
Is Store image Mode Active ?
Yes
No
237
Read the Image Title
238
Determine the Next Available Location for Storing
239
Set-Up Header for Stored Image Frame
240
Store Data to Mass Storage
241
Set Complete Command for Store Image
End
Start
242
Is the Delete Image Mode Active ?
Yes
No
243
Determine Image Frame Selected for Deletion
244
Re-Pack Image Frames
245
Update the Image List and put Update Information on the Global Bus
248
Set Complete Command for Delete Image
Start
249
Is the Delete Image Mode Active ?
Yes
No
250
Initialize all Image Data
251
Update this Information to the Global Bus Memory
252
Set Complete Command for Delete Image List
Start
253
Is Receive Image Mode Active ?
Yes
No
254
Is Direct Link Mode Active
Yes
No
255
Process Data for the Direct Receive Data Mode
256
Process Data From Indirect Receive Medium
257
Remove Error Correction
258
Store Image Data
260
Updata Image list to the Global Bus and Set Complete Command for Receive Image

Fig. 10b

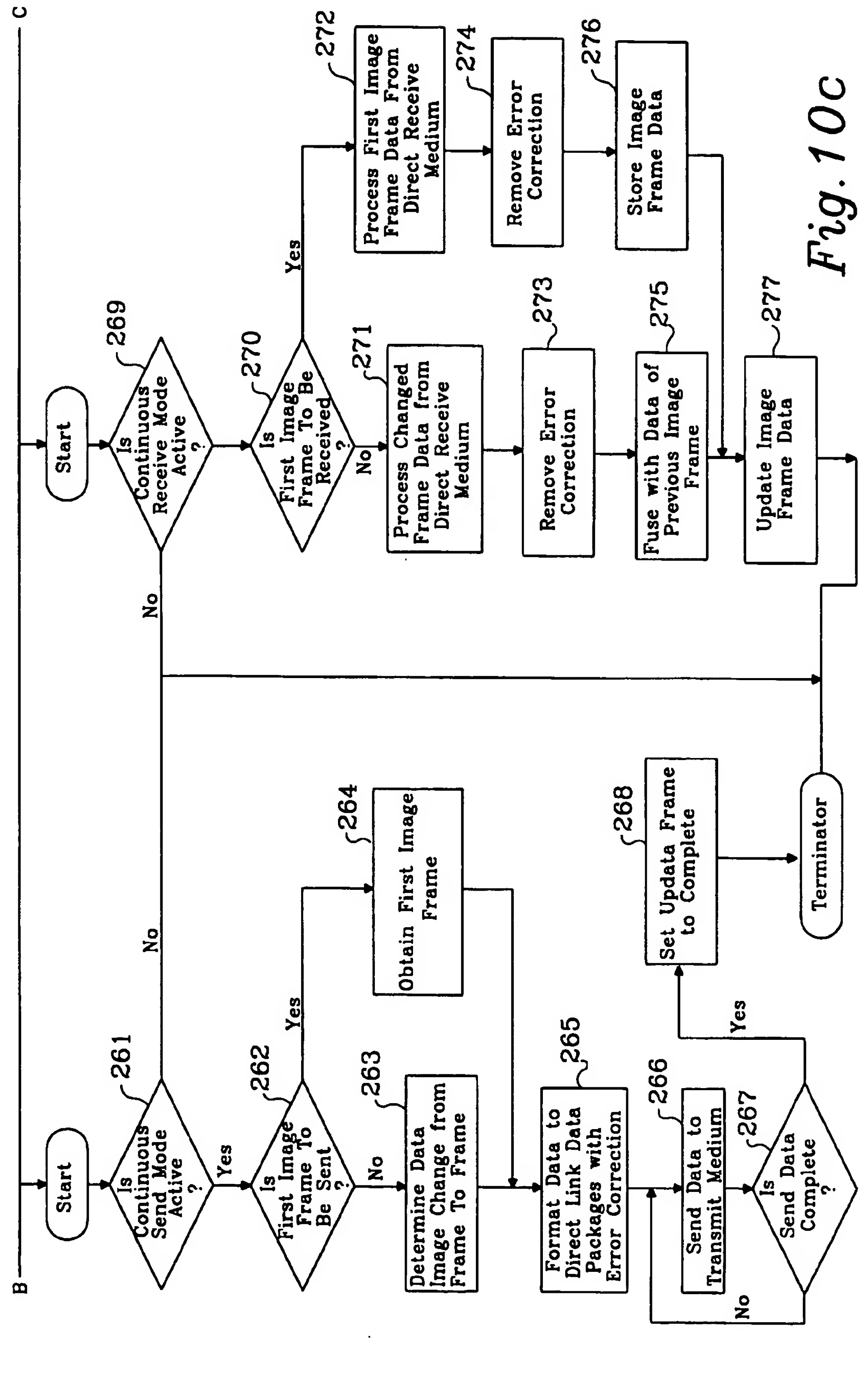

B
C
Start
Is Continuous Send Mode Active ?
261
Yes
No
Is First Image Frame To Be Sent ?
262
Yes
No
Obtain First Image Frame
264
Determine Data Image Change from Frame To Frame
263
Format Data to Direct Link Data Packages with Error Correction
265
Send Data to Transmit Medium
266
Is Send Data Complete ?
267
Yes
No
Set Updata Frame to Complete
268
Terminator
Start
Is Continuous Receive Mode Active ?
269
Yes
No
Is First Image Frame To Be Received ?
270
Yes
No
Process Changed Frame Data from Direct Receive Medium
271
Remove Error Correction
273
Fuse with Data of Previous Image Frame
275
Update Image Frame Data
277
Process First Image Frame Data From Direct Receive Medium
272
Remove Error Correction
274
Store Image Frame Data
276

Fig. 10c

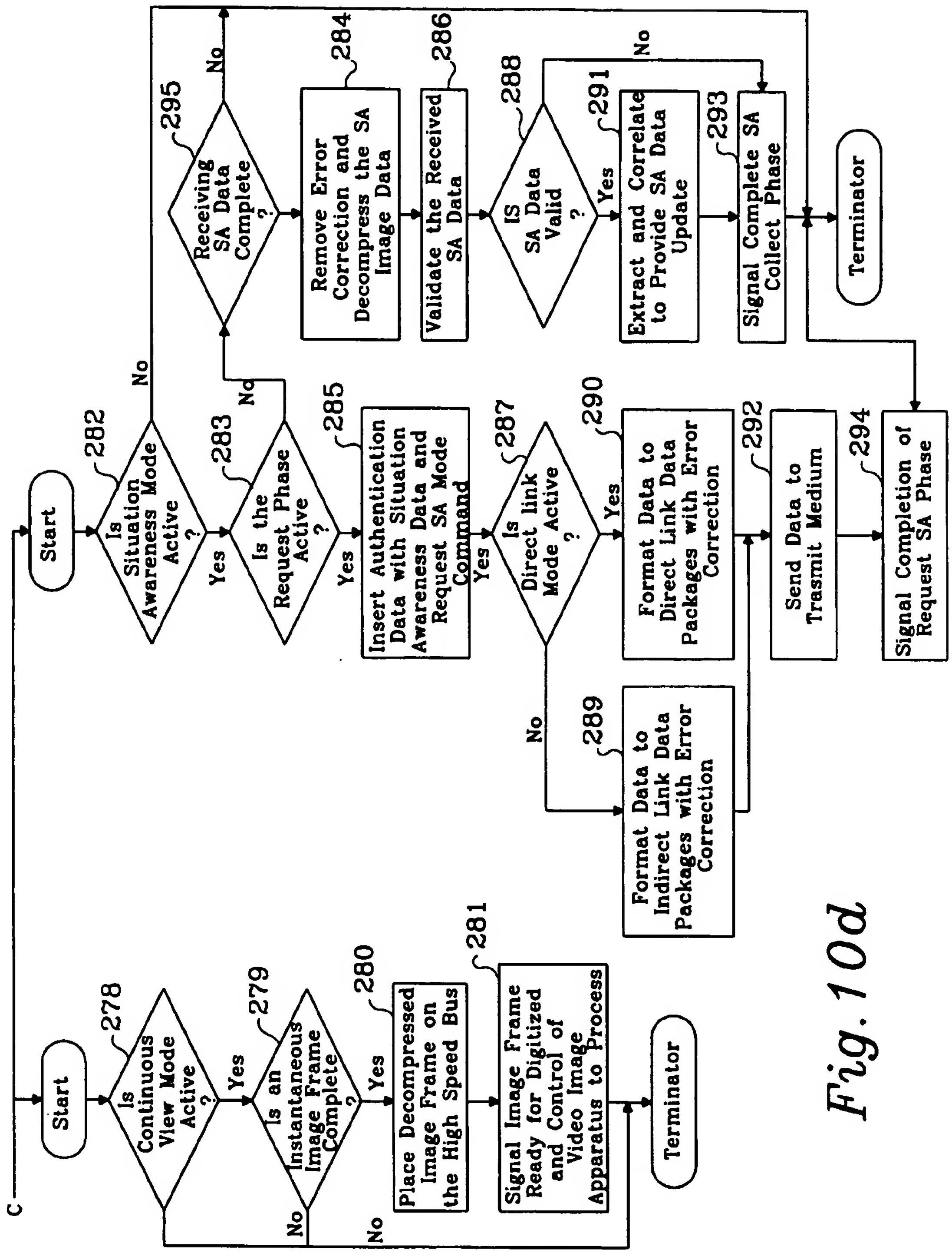

C
Start
Is Continuous View Mode Active ?
278
Yes
No
Is an Instantaneous Image Frame Complete ?
279
Yes
No
Place Decompressed Image Frame on the High Speed Bus
280
Signal Image Frame Ready for Digitized and Control of Video Image Apparatus to Process
281
Terminator
Start
Is Situation Awareness Mode Active ?
282
Yes
No
Is the Request Phase Active ?
283
Yes
No
Insert Authentication Data with Situation Awareness Data and Request SA Mode Command
285
Is Direct link Mode Active ?
287
Yes
No
Format Data to Indirect Link Data Packages with Error Correction
289
Format Data to Direct Link Data Packages with Error Correction
290
Send Data to Trasmit Medium
292
Signal Completion of Request SA Phase
294
Receiving SA Data Complete ?
295
No
Remove Error Correction and Decompress the SA Image Data
284
Validate the Received SA Data
286
IS SA Data Valid ?
288
Yes
No
Extract and Correlate to Provide SA Data Update
291
Signal Complete SA Collect Phase
293
Terminator

Fig. 10d

EMBEDDED MISSION AVIONICS DATA LINK SYSTEM

OBJECT OF THE INVENTION

This invention relates to a data link for a military aircraft or vehicle, and more specifically to a data link system which receives, transmits, recognizes, prioritizes, configures, and presents many different types of information and provides the flight crew the capability to extend their window of visibility in terms of imagery and precision data to other platforms.

BACKGROUND OF THE INVENTION

When a modem military aircraft flies a mission it is oftentimes necessary to fly in concert with other aircraft. This synchronous flying requires extensive planning of a route with respect to known threats, satisfactory knowledge of the threat location, and information on the capabilities of the threat. The mission planning must also include the coordination of activities among the aircraft. In order to execute a complex mission against a dangerous target, it is important that there are two-way lines of communications between all the aircraft as well as between the aircraft and a ground station.

Many modem military aircraft are equipped with a digital map system which displays to the pilot the characteristics of the terrain around the aircraft, the location of the aircraft relative to the terrain, the flight path of the aircraft, and the location of the target relative to the aircraft. Other information displayed to the pilot may include the visibility of the aircraft relative to the target and possible flight paths for the aircraft to avoid detection by the threat. The disadvantage of a digital map system is that the map image is pre-processed and does not include dynamic elements of real-time mission scenes.

Currently, military aircraft are limited on the amount of information which is received and transmitted from other aircraft as well as from a ground station. These transmissions are mostly limited to voice communications. Limited means also exist to transmit some mission information to an aircraft. As currently configured, the voice communication and mission updates require two separate systems in order to process the different types of information. The need to operate two separate systems during a mission can be a burden on the flight crew. A system which provides for greater transmission and receipt capability of flight and mission information, would only be desirable in an aircraft data link if the use of these functions did not add significantly to the workload of the flight crew. The system would have to identify the types of information being received, automatically prioritize it, and compile it in a format for the flight crew to easily access on their in-cockpit display screens.

When a military aircraft is flying a mission within the vicinity of a threat, certain types of information can increase the likelihood of the success of the mission. The effectiveness of the flight crew would be enhanced by providing means for the aircraft to communicate in many different modes and provide constant updates of each other's position as well as other mission related data. There would also be an advantage to transferring video imagery information between aircraft. One example is where a scout ship flies on ahead of the rest of the aircraft to perform some kind of reconnaissance on a target. This scout ship can then transmit back to the other aircraft as well as a ground station real-time video imagery of the target to provide up to date conditions

at the threat site. Another advantageous feature would be the ability to automatically, without significant attention from the pilot, transmit updated mission information among the aircraft as well as to a ground station.

SUMMARY OF THE INVENTION

Disclosed herein is a datalink system for a vehicle which increases both mission situation awareness and capability, and at the same time reduces the workload of the vehicle crew by providing a variety of automatic functions which identify and prioritize digitized data which is received and transmitted by the vehicle. The system includes a communications apparatus which provides the vehicle two-way voice and digitized data communications. A data signal processing apparatus in connection with the communications apparatus, identifies information received externally by the vehicle, and provides to the communications apparatus, information which has been generated internally. A datalink controller directs the processing of the information received externally and the information generated by the vehicle with the datalink system. Also included is a prioritization apparatus connected to the data signal processing apparatus which prioritizes the internal information, decodes external information according to the type of mission the vehicle is on, and displays image classification. A memory, which is accessible by the datalink controller and the data signal processing apparatus, stores information generated internally and received externally. A display apparatus processes the internally and externally generated information and provides it in the proper format to the pilot for viewing. The pilot may annotate the images which appear on the cockpit displays and either store those annotated image in memory or transmit them externally.

Other objects, features and advantages of the invention will become apparent to those skilled in the art from the description of the preferred embodiment, claims and drawings hereof, wherein like numerals refer to like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a mission avionics system structure.

FIG. **2** is a block diagram of the Embedded Mission Avionics Data Link System.

FIG. **3** is a flow chart of the mission avionics graphic generator.

FIG. **4** is a flow chart depicting the operation of the moving map generator.

FIG. **5** is a block diagram of the mission avionics data link control.

FIG. **6** is a flow chart of the image data annotation process.

FIG. **7** is a flow chart of the prioritization and authentication process.

FIG. **8** is a flow chart depicting the operation of the set up and control of the transmit/receive medium.

FIG. **9** is a flow chart depicting the operation of the digitize and control of video image apparatus.

FIGS. **10*a–d*** is a flow chart depicting the operation of the data signal processing apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Disclosed in FIG. 1 is a block diagram of a mission avionics system structure for a military aircraft. At the core

of the system there are two master controller processor (MCPU's) units 301 and 302 which process all the information received from pilots as well as the aircraft systems and sensors. The two MCPU's process input and output signals for different aircraft systems, and also act as redundant paths for the critical aircraft functional modules. Although this is not a complete diagram of the avionics system, all the systems necessary for a description of the present invention are presented. The sensors and systems input signals to the MCPU's are either received over the avionics bus 305 or through a direct connection. Transmitting signals on the avionics bus 305 are communications sub-systems 306, the navigation radio (TACAN) 307, the embedded global positioning and inertial navigation system (EGI) 308, the mast mounted sight system (MMS) 310 which provides television video and thermal video images outside the aircraft, and the improved data modem (IDM) 138. The memory data unit (MDU) 3 is also connected to the avionics bus, but also has a high speed dedicated bus to MCPU 301. The avionics bus disclosed is a well known bus structure to those skilled in the art.

In direct connection with the MCPU 301 is the video tape recorder (VTR) 316 which records and plays back events on board the aircraft. In direct contact with MCPU 302 is the optical display assembly (ODA) 330, for night vision viewing the ANVIS Display Symbology Subsystem (ADS) 334, and the radar altimeter (RALT) 336. Also in connection with MCPU 302 are the aircraft survivability subsystems 338 and the armament assembly and subsystems 340. The aircraft survivability subsystems provide the threat status and receives system set-up commands from the pilot through the MCPU 302. The armament assembly and sub-systems 340 provide weapons status and receive weapons activation commands from the pilot through the MCPU 302.

Video images which appear on the multi-function displays (NFD) 139 and information which appears on the radio frequency display (RFD) 314 are output from both MCPU's. Both MCPU's also receive input commands from various keyboards (324) and switches (326) in the cockpit and also output signals to the caution/warning/advisory audio subsystem 328 in the cockpit.

In the preferred embodiment of the invention, the embedded mission avionics data link system of the present invention is embedded in MCPU 301. This system can also be designed so that the data link system is redundant and embedded in both MCPU's 301 and 302. A block diagram of the Embedded Mission Avionics Data Link System is shown in FIG. 2. This system is described herein as used in a military aircraft, however one skilled in the art would realize that this data link system can be applied to other types of aircraft and vehicles.

In FIG. 2, the global bus interface 5 is the primary circuit card assembly (CCA) to interface within the MCPU's. The global bus links memory on one CCA with memory on another CCA. The memory linked by the global bus is referred to as shared memory. Shared memory is used by a CCA to read or write data to another CCA. All inter CCA communications on the global bus are controlled and arbitrated by the global bus interface hardware.

The pilot command processor 2 receives the process commands from the cockpit through such devices as bezel switches, multi-functional buttons on the keyboard unit, switches on the pilot cyclic grip, push buttons and switches on control panels, a video annotation device such as a mouse, or through other switches and buttons in the cockpit. The pilot command processor 2 receives the pilot commands through the various devices in the cockpit and transmits command signals to other components in the system.

One component which receives command signals from the pilot command processor 2 is the mission avionics graphics generator 4. The mission avionics graphics generator also receives inputs from a variety of other sources which include a mast mounted sight external video camera, thermal image aircraft sensors, mission avionics display data stored in memory, and moving map video from the digital map generator 6. In response to the command signals from the pilot command processor 2, the graphics generator apparatus generates display pages made up of information from the other inputs after a video switch is set to the appropriate video output.

The pilot may choose to view any of a number of mission avionics image pages. The pilot selects which image are to be viewed from the moving map generator 6, which provides map imaging information in terms of charts, digitized terrain elevation, and scanned image placed on the global bus 5. Situation awareness data is provided to the moving map generator 6 using information from the data signal processing apparatus 20 and this situation awareness data is included with the map images. This situation awareness overlay data includes platform mission identification, present position, heading, and other significant platform information. The situation awareness data is overlaid as icon symbols on the chart or terrain elevation image provided from the moving map generator 6. With the selection of an icon symbol, the pilot will learn specific information about the platform represented by the icon such as platform ID, direction of movement, fuel remaining, mission status, and armament status.

The mission avionics data link control 10 acts as a command signal interpreter and a control device for the other components in the system based on communication medium configuration and status and data link commands. Almost any act the pilot wishes the system to perform is first processed through the mission avionics data link via a command signal from the pilot command processor 2. These commands include direction for the retrieval and storage of data in memory, establishing a configuration of the transmit and receive medium 16, determining the active modes of operations, and basically directing the operation of the components within the system structure.

The image data annotation apparatus 12 is one of the components which receives command signals from the mission avionics data link control apparatus 10. The annotation apparatus also receives avionics and mission data from other modules within the MCPU. This particular component will pack data to be annotated for each unique image page and allow the pilot to incorporate free text to denote features of the images which appear on the cockpit MFD's. For instance, the pilot may be viewing an image of the target and may wish to add written or symbolic information to that particular image which would be a benefit to other aircraft which receive this image information.

One of the novel features of the present invention is the ability of the data link to recognize and process mixed modes of data, for example, video and precision data. This system has the ability to capture, store, view, receive, transmit, combine, delete, and retrieve many different types of information and re-configure mission and equipment with minimal pilot interaction required. Data signal processing apparatus 20 is the initial processing unit for all types of information received by the aircraft and the final processing unit for all information that is transmitted to other aircraft or

to a ground station. This apparatus is connected to the transmit/receive digitize data medium **138** and identifies and processes information being received or transmitted by the aircraft. This information includes video image information, mission avionics specific data, and mission avionics equipment update information. The data signal processing apparatus **20** directs the information to the appropriate component of the system after being validated by the prioritization and authorization apparatus **14**.

The prioritization and authentication apparatus **14** is used to first authenticate any information which is received externally. All information which is received from outside has to be decoded and this apparatus would certify that the information was transmitted from a legitimate source. Secondly, any information which is received either externally or generated internally is prioritized according to the particular mission which the aircraft is on and the structural order defined for all image display pages. Received information which is of a high priority is stored such that it is easily accessible by the pilot. Other low priority information is stored in the available memory or filtered out.

When image information is to be displayed, that particular information must be converted to an analog video signal from digital form. If the video image is in analog signal form, it must be converted to a digital bitmap before it can be stored in memory or transmitted externally. Digitize and control video image apparatus **18** performs this function. This portion of the apparatus receives mission avionics primary video data from the mission avionics graphics generator as well as image data over the high speed bus **21** from data signal processing apparatus **20**. Digitize and control video image apparatus processes the data based on video image control command data received on the global bus **5**. The digitize and control video apparatus performs a variety of sub-functions which include capture video **135**, display video **136**, or overlay video **137**. The capture video sub-function **135** allows the pilot by a switch activation in the cockpit to capture a video image currently displayed on the MFD. During operation of the aircraft, the pilot may be viewing an image from mission avionics graphics generator, moving map generator, digitize and control of video image apparatus, the mast mounted sight video, as well as an image received from an external source. The pilot may capture this single video image and store it in memory, or transmit it externally. The pilot may also add video and data annotations to the captured page. In the display video mode, video is displayed to the pilot from the source corresponding to command selected. It may be a single image file of video retrieved, continuous video images from continuous real time receiving from external sources, the mast mounted sight video, or from mission avionics graphics generator and moving map generator source. The overlay video sub-function works in conjunction with the image data annotation apparatus to allow the pilot to annotate by modifying the bitmap image to include written words or symbols on the images that are currently being displayed on the MFD.

The transmit and receive medium **138** is the electronic apparatus which actually receives and transmits the digitized data. This part of the system is actually made up of two electronic devices, a radio and a data modem. The direct link mode is used to pass information via radio to other aircraft or a ground station. The indirect link mode will use a data modem and a radio to pass information to other aircraft via a network server. The pilot can choose between the two physical data link modes depending on the mission, type of data to be received or transmitted, or the ultimate destination of the information. The configuration of the transmit/receive medium is established by the setup and control of transmit/receive medium apparatus **16**. The setup and control of the transmit/receive medium apparatus **16** receives date link/medium commands through global bus **5** to set up the medium to either receive or transmit in digitized data image mode, other digitized data mode, or voice mode.

Also in connection with the global data bus **5**, are a series of apparatus to update the appropriate portion of the mission plan stored in memory. When mission information is received and processed by image data signal processing **20**, depending on the type of information, it is then transmitted to either flight plan update and activate **110**, battlefield graphic update and activate **111**, target update and activate **112**, prepoint update and activate **113**, or communication update and activate **114**. From here, the information is transmitted to the mission avionics graphics generator and this information is displayed to the pilot. At any point after this, the pilot can then update the current mission information and store the newly updated mission data in the MDU **3**.

When digitized video data and annotated data are received or transmitted from the aircraft, different operations must be performed on the data so that it is readable and recognizable by the sending source or by the intended receiving targets. Apparatus have been provided to perform these functions. When data is received by the aircraft it usually has been packed in a compressed form with error correction implanted. When uncompressed data is transmitted it needs to be compressed and provided with data error correction and then packed into subframes. Data compression/decompression apparatus **131** has been provided to perform this function. Information received and transmitted through the airways may be susceptible to noise, so the error correction apparatus **132** has been provided to insert error correction in data when transmitted, and remove the correction data when received. When image data is captured for storage or transmission to other aircraft, it is processed by the image data from capture, receive, and transmit apparatus **134** to incorporate data annotations with the digitized video image data and put this complete set of image data in the proper format. When the image receiving mode is active, the capture, receive and transmit apparatus **134** will process the received image data from the communication port and place it in an actively working partition memory to be processed by other apparatus which reside in the structure of data signal processing apparatus **20**. Through the apparatus **20**, the apparatus **134** will provide the feedback signals to the mission avionics data link control apparatus via the global bus **5**. Finally image data storage and retrieve interface apparatus **135** acts as a two way medium between the MDU dedicated bus **7** and the MDU **3** to store and retrieve data.

Now referring to FIG. 3, a more detailed block diagram of mission avionics graphics generator has been provided. The graphics generator receives command signals from the pilot command processor in the form of a MFD display page select signal, a display page control signal, as well as a video annotation command signal. The MFD display page select signal and the display page control signal are received by the MFD primary video processor **41** which outputs a control signal to the video switching apparatus **46**, as well as a selected internal mission avionics display page to the mission avionics display frame generator **43**. Each unique video image displayed on the MFD is referred to as a display page. The MFD display page select and the display page control are commands to the graphics generator to display a particular image page. The video annotation command is received by the overlaid video data generator **42**. A video

annotation command is a command to add additional layers of information to a particular image that is being displayed. The mission avionics display frame generator **43** receives the mission avionics display data and generates individual display pages. Coming into the avionics graphics generator **4** are signals from the mast mounted sight video and the moving map video data. The mast mounted sight provides video images from the externally mounted video camera or thermal imaging of the surrounding environment. These video signals are input directly into the video switch **46**. Video switch **46** acts as the video signal control to channel the video source, and mix video signals with the mission avionics primary video data.

In operation, MFD display page select and digital page control signals are output from the pilot command processor and input into the MFD primary video processor **41**. These signals control which video image will appear on the MFD in the cockpit. Also initiated from the cockpit is a video annotation command in which the pilot manipulates images which appear on the MFD. In the situation where the pilot annotates the mission avionics display images, these two sources of information are mixed in combiner **44**. An image page for the combined mission avionics display data and the video annotation is then generated at graphics generator video **45** which then outputs the image page to switch **46**. As described previously the pilot has a choice of which images would appear in the cockpit, which are captured for storage, and which images will be transmitted externally. The switch **46** allows the pilot to choose between the mission avionics display data, moving map video data, the mast mounted sight thermal/TV imaging video, or combined video. The pilot also may view the aircraft's current situation relative to the surrounding terrain and mission situation from the moving map video data.

Disclosed in FIG. 4 is a flowchart which describes the operation of the moving map generator. The use of digital maps in modem aircraft is well known. Digital information about the terrain surrounding the aircraft, potential threats, and targets is stored in a digital database. As a pilot flies on a mission his current position relative to the terrain, the threats, and the target is shown on a display screen. Included with the terrain image displayed to the pilot are video symbols representing the location of other digitally detected and identified platform. This type of information is known as situation awareness data. Situation awareness data is periodically received by the data signal processing apparatus **2** either automatically or upon request of a situation awareness update. This data is further processed through situation awareness overlay data processor **8**. This processing apparatus provides situation awareness data to the moving map generator **6**. This information is combined with the map images in a manner which is known to those skilled in the art.

In the initial step, **62**, of FIG. **4**, a query is made as to whether the situation awareness display has been selected. This particular image is either a chart or the digitized terrain surrounding the aircraft which includes an overlay of the situation awareness data. If the selection mode is active, the situation awareness data from situation awareness overlay data processor **8** is processed at step **63**. Because the map image is limited in the amount of area it can show, the situation awareness data at step **64** must be analyzed to determine which of this information falls within the map range currently displayed to the pilot. At step **65** the situation awareness image ID's are correlated for the map overlaid symbols. The situation awareness source locations are then converted to a screen coordinate at step **66**. Then at step **67** the bitmap is modified to include the situation awareness symbols. Finally, at step **68** the map video data is then updated. This imagery is then transmitted to the mission avionics graphics generator to be viewed upon selection by the pilot.

In FIG. **5**, a block diagram is provided of the mission avionics data control apparatus which processes the command signals from the pilot and provides the process activation signals to the other components in the data link system. As described above, the pilot selects these commands through a variety of control switches and buttons located on panels, pilot control grips, and any other devices in the cockpit. The commands may come from a keyboard, bezel switches on the MFD's, pilot cyclic grips, and any other control panels in the cockpit which are used for processing information. The link source **101** receives the communication medium status on the aircraft and a command from the pilot command processor which directs the configuration of the medium. A data link command signal is also received at the data link active mode processor **102** in order to establish whether the medium is in the transmit or receive mode. Signals are generated by both the **101** and **102** processors which direct the communication medium control command generator **103** to properly configure and set up hardware control for the transmit/receive medium **138**. Specifically, the link source processor **101** sends the signal to activate the radio link and/or the modem, while the signal from data link active mode processor **102** properly configures the mode for the communication device which has been activated.

The data link active mode processor **102** generates all the other command signals for directing the components of the system to perform particular tasks. In response to a signal from data link active mode processor **102**, digitize and control video image apparatus control processor **104** generates command signals for initiating the active control mode of the digitize and control of video image apparatus. Processor **104** receives feedback command status from the digitize and control of video image apparatus **18**. According to a data link command generated in the cockpit, processor **102** directs the signal processor **105** to generate specific commands for active modes of the data signal processing apparatus **20** and to receive feedback signals of the operational mode states. A control command of the optional page index is generated from command signal generator **106** for directing the operation of image data annotation apparatus **12**. When the datalink command is either capture image, receive image, or continuous receive/view image, processor **102** directs the prioritization and authentication processor **107** to generate a prioritization and authentication control signal to apparatus **14**. Command signal generator **108** directs the operation of the situation awareness overlay data apparatus **8** when the situation awareness auto mode or update mode is active. Command signal generator **109** directs the operation of the flight plan update and activation apparatus **110**, battlefield graphics update and activation apparatus **111**, target update and activation apparatus **112**, prepoint update and activation apparatus **113**, and communications update and activation apparatus **114**. Further, command signal generator **110** provides control signals for the operation of mission avionics graphics generator **4** to generate specific display page selected by the datalink command. Disclosed in table 1 is a full list of commands executed by the mission avionics data link control apparatus.

TABLE 1

Capture Image	Store Image
Send Image	Preview Image
Receive Image	Continuous Receive/View Image
Update SA	Delete List
Error Correction ON/OFF	Flight plan Update
Battlefield Graphics Update	Target Update
Prepoint Update	Communication Update
Select Image	Situation Awareness Update
Situation Awareness Auto Mode	Image List
	Image Resolution

The operation of the image data annotation apparatus **12**, is described in the flowchart of FIG. **6**. The image data annotation apparatus is a tool for the pilot to annotate an image that is currently appearing on a cockpit display after it has been captured or received and is residing in the digitize and control video image apparatus. In response to the command signal from the mission avionics data link control **10**, the image data annotation apparatus receives a signal from the image data annotation signal processing element **106** to indicate the active display page image (i.e., one of 70 image pages—navigation display pages, map image display pages, mast mounted sight display pages, weapon display pages, communication display pages, and other pages) and correlates this optional page index with a resident data base to extract a set of core parameter data to provide the digitize and control video image apparatus. This is done at step **121**. In step **122**, based on the captured page, as indicated by operation page index, the index is used to correlate with a resident database to determine the unique parameter data set that is associated with the page captured by the pilot. At step **123**, the data associated with the captured page is retrieved from the avionics and mission data inputs and included with the pilot annotation text data. At **124**, the annotated image is transmitted to the digitized and control of video image apparatus for viewing, and to the data signal processing apparatus for storing, and transmission.

Before any information received from outside the aircraft can be used by the data link system, it must first be authenticated. Once it is authenticated, then this information is prioritized according to parameters established for the particular mission the aircraft is on as well as the particular source of information. FIG. **7** discloses a flowchart which shows in detail the steps performed during the prioritization and authentication process. First at step **141** an inquiry is made as to whether this particular process is enabled as indicated by the prioritization and authentication controls signal. In the datalink system, a command (such as captured image, receive image, or continuous receive image) is received from the mission avionics data link control to start this process. If the answer is yes, at step **142** a second query is made as to whether the capture image mode is active. If the capture mode is active, it means that the pilot first captures the video image currently displayed on the MED. This information does not need to be encrypted and decrypted, so at step **143** the information is given a priority depending on the type of display page captured and mission of the aircraft is on. At step **144**, image information which has been captured and authenticated along with mission identification and platform identification is encrypted and provided to the data signal processing apparatus to place in the header frame of the captured image data file. At step **147** the output of priority and authentication data is transferred to the global bus to be accessed by the data signal processing apparatus **20**.

If the capture mode is not active at step **142**, this means that the datalink system is in the data receive mode and is receiving information from an external source via the transmit/receive medium. A query is made at step **145** as to whether the request for validation of authentication is active. If it is, the data which has been received is decrypted at step **146** to determine the Mission ID and the Platform ID of the external source which transmitted the information. Once the data has been decrypted, at step **148** the data is correlated with the mission database. If correlation can be derived from matching with known mission identification and platform, a signal to indicate the completion of authentication and validation of the received image is provided. The information requested is then placed on the global bus interface at step **150** for further processing by the data signal processing apparatus **20** to the appropriate destination.

FIG. **8** is a flowchart describing the operation of the set-up and control of the transmit/receive medium apparatus **16**. At step **160**, the datalink medium configuration provided by the mission avionics data link control apparatus **10** on the global bus interface is read. From this command the configuration of the transmit/receive medium is determined at step **161**. A query is then made at step **162** as to whether the automatic receive and transmit mode override has been set. If it has, second query is made at step **167** as to whether the transmit/receive mode has been set. If the mode is set, at step **168** the bus command and hardware control are set up to be ready for transmitting and receiving digitized data. If the transmit/receive mode is not set, a query is made at step **169** as to whether the transmit/ receive mode transitions from on to off or the voice mode has been selected. If either is true, at step **170**, the bus command and hardware controller is reset to terminate the digitized mode of operations. If the transmit/receive mode does not transition from on to off, the process goes to end.

If the mission avionics auto mode override is not set at step **162**, a query is made at step **163** as to whether the direct datalink mode is set. The direct datalink uses radio to transmit the digitized data of image files without being required to interact with a data modem. If the direct datalink mode is set at step **164**, command and control signals are transmitted to the radio to operate in the auto receive and transmit mode. If, at step **165**, the direct datalink mode is not set, the indirect datalink is active. The datalink functions are performed through a network server. At step **165**, a set up command is sent to the data modem and radio to command operations in the video imaging transfer mode. At step **166**, the control of operation mode for the radio is set for use in an indirect datalink system.

A flowchart describing the operation of the digitize and control video image apparatus is provided in FIG. **9**. Included with this apparatus are three functional modules, capture video **135**, display video **136**, and overlay video **137**. In operation, the command signals and data annotation are first read from the global bus interface at step **181**. At step **182** the active mode for this particular component is determined. At step **183** an inquiry is made as to whether the power-up mode is active. If the power-up mode is active, a process initialization is performed at step **184**, a power-up sequence is performed at step **185**, and the test results of the power-up are put on the global bus interface at step **186**. If the power up mode is not active, then the query is made at step **187** as to whether the capture video mode is active. If the capture video mode is active, the video image currently appearing on a cockpit display is digitized at step **188**. The image frame is then modified to include the video data annotations at step **189**. The captured image frame with the video annotations is then placed on the high speed data bus **5** to the data signal processing apparatus **20** at step **190**. The

captured image frame is then converted to a video signal for rendering at step **191**. The query is then made at step **196** as to whether the video switch is set to internal. If it is not, it is then set to internal at **197**.

If the capture mode is not active, then the query is made at step **192** as to whether the view mode is active. If it is, at step **193**, image frame data transmitted by the data signal processing apparatus on the high speed bus is placed in the image buffer. At step **194** the image frame is then modified to include data annotations. At step **195** the modified image frame is then converted to a video signal for image rendering. Once again at step **196** the query is made as to whether the video switch is set to internal and if it is not, it is then set to internal.

A query is made at step **198** as to whether the active continuous viewing mode is active. If it is, at step **199** the updated image frame from the high speed bus is first processed. The image frame is then modified to include video data annotations at step **220**. The continuously modified image is then converted to a video signal for rendering at step **221**. As with the other modes, the query is made as to whether the video switch is set to internal and if it is not, the switch is set. The main function of the digitize and control video image apparatus is to prepare video images for viewing by the pilot in the cockpit or to convert video images generated internally or received externally to digital bitmaps for storage in memory or transmission externally.

A final query is made at step **222** as to whether the continuous capture mode is active. If the answer is no, the process ends. If the answer is yes, the mission avionics data is first digitized at step **223**. At step **224**, the image frame currently captured is annotated to include the video data annotation. At step **225**, the captured image with the video annotations is placed on the high speed bus to the data signal processing apparatus **20**. At step **226** the image frame is then converted to a video signal for viewing. As with the other sub-programs, the query is then made at step **196** as to whether the video switch is set to internal, and if it is not, it is switched to internal at step **197**.

The detailed operation of the data signal processing apparatus is disclosed in a flowchart of FIGS. **10*a–d***. The function of the data signal processing apparatus is to identify and process the different types of information which are received and transmitted through the transmit/receive medium **138** and stored in the MDU **3**. This component also stores the various types of information to memory or updates the current mission plan. The apparatus performs several processes in parallel. The data signal processing apparatus also provides digitize and control video image apparatus **18** with digital bitmaps to convert to video signals to display on the MFD.

In FIG. **10*a***, initially commands for image data signal processing are transmitted from the mission avionics data link control **10** and are read at step **201**. At step **202**, it is determined which modes are active. If the power-up mode is active, according to the query at step **203**, an initialization and setup of the configuration for image data signal processing is performed. At step **205**, a power-up test is performed. At step **206**, the results of the power-up test are then placed on the global bus interface and a complete command for the test is set at step **207**. If the data signal processing apparatus is in its operational mode, the first query at step **208** is whether the image capture mode is active. If the answer to that is yes, the digitize image data from the high speed bus is received at step **209**. At step **210**, the index compression is computed based on the image resolution command to provide image contrast level and image transmit/receive time. The image data is then compressed and at step **211**, fused with the data annotations. The capture mode is then complete at step **212** and the image data is stored in an active buffer and is ready for transferring to the MDU **3** or transmitting externally.

The process to view an image begins at step **213**. If the view image mode is active, at step **215** the pilot determines which selected image frame is for viewing. At step **216** the chosen image frame is decompressed and placed on the high speed bus to the digitize and control image apparatus **18**. At this point the image is converted to a video signal in analog form to display on a MFD for viewing. This process is then complete at step **218**.

The procedure to send an image begins at step **219**. Once it is determined that the send image mode is active, a query is then made at step **230** as to whether the direct link mode is active. If it is not, the data is formatted to an indirect data package with error correction at step **233**. If the direct mode link is active, at step **231** the data is formatted for the direct link data package with error correction. At step **232**, with either the indirect or direct data format the data is sent to the transmit/receive medium. At step **234**, the query is made as to whether the data send is complete. The procedure is then completed at step **235**.

The process to store an image begins at step **236** of FIG. **10*b***. Once it is determined which image is to be stored, the image title is read at step **237**. At step **238**, it is determined where the next available location for storing is. At step **239**, a header is set up for the stored image frame and at step **240** the image is sent to the MDU **3**. At step **241**, the process is complete.

The procedure to delete an image begins at step **242**. At step **243**, it is determined which image frame has been selected for deletion. The image is then deleted and the remaining image frames are repacked at **244**. At step **245**, the image list is updated to indicate the deletion of a selected image frame and the updated information is then put on the global bus memory. At **248** the process is complete.

The process to delete an image list stored in memory begins at step **249**. At step **250**, all image data is first initialized. At step **251**, this information is then updated on the global bus memory. At step **252** the process is complete.

The process to receive an image frame begins at step **253**. At step **254**, a query is made as to whether the direct link mode is active. If the direct link mode is active, the data is processed from the direct receive medium at step **255**. If the direct link mode is not active, preparations are made at step **256** to process data from the indirect receive medium. Once the image is received, the error correction is removed at step **257** and the image data is stored at step **258**. At this point the image list to the global bus memory is then updated. At step **260** the steps are complete.

The process for a continuous send of images begins at step **261** of FIG. **10*c***. At step **262**, the query is made as to whether the first image frame is to be sent. If the answer is yes, at step **264** the first image frame is obtained. If the answer is no, at step **263** it is determined what is the change in data image from the current frame to the previous frame. Data representing the first image frame or changes from the current frame to the previous frame are formatted at step **265**. The formatted data is then sent to the transmit medium at step **266**. At step **267** the query is made as to whether the transmit is complete. If it is not, the procedure is continued with step **266**. If it is yes, the process is then complete.

The continuous receive image process begins at step **269**. At step **270**, a query is made as to whether the first image

frame is to be received. If the answer is yes, at step **272** first image frame data is processed from the direct receive medium. At step **274**, the error corrections are removed and at step **276** the image frame is stored in memory. If the answer is no as to whether the first image frame is to be received, at step **271** changed frame data is processed from the direct receive medium. At step **273** the error correction is made and at step **275** the data is fused with other data from the previous image frame. At step **277**, the image frame data is updated.

In FIG. **10***d*, at step **278** the query is made as to whether the continuous view mode is active. If it is, a second query is made as to whether an instantaneous image frame is complete. If the answer is yes, the decompressed image frame is placed on the high speed bus at step **280**. At step **281**, the image frame is ready to be transmitted to the digitize and control of video image apparatus to further process. The process is then terminated.

At step **282**, the query is made as to whether the situation awareness mode is active. If it is not, the process ends. At step **283**, a second query is made as to whether the request phase for situation awareness data is active based on requests from other aircraft or periodically on aircraft request. If it is active at step **285**, authentication data is inserted with situation awareness data including requested SA data command. A query is then made at step **287** as to whether the direct link mode is active. If the answer is no, at step **289** the data is formatted to indirect link data packages with error correction. If the answer is yes at step **290**, the data is formatted to direct link data packages with error correction. At step **292** the data is sent to the transmit medium. At step **294**, a signal is sent noting completion of the requested phase.

Returning to step **283** if the requested SA phase is not active, at step **295** the query is made as to whether receiving SA data is complete. If it is complete at step **284**, the error correction is removed and the situation awareness image data is compressed. At step **286**, the situation awareness data is validated. At step **288**, a query is made as to whether the situation awareness data is valid. If it is valid, at step **291** the situation awareness data is extracted and correlated to provide a situation awareness data update. At step **293** the completion of the situation awareness collection phase is signaled. The process is then terminated. Returning to step **295**, if the receiving SA data is not complete, the process is terminated.

In operation, the avionics data link system operates in a number of modes which will be described in detail below. The novel feature of the present invention is that a data link system has been created which allows the automatic processing of multiple forms of data and analog video data, digitized video data, overlaid video annotation data, free text and precision mission avionics data. No prior art systems known have demonstrated the ability to process multiple kinds of data in real time and let the pilot of an aircraft transmit and receive mixed mode data, update flight plan, mission related data, communication operational data, and situation awareness data. Another novel feature of the present invention is the capability to automatically and instantaneously determine the stage of the mission and capture the image of mixed data for storage and transmitting to other platforms.

In the situations where the pilot wishes to view video generated by television system or thermal image systems of the mast mounted sight, annotate those images, and then store them in memory, the procedure is as follows. In the cockpit, the pilot first chooses the mast mounted sight mode to activate by pressing the MMS bezel key on the MFD to view the video from the mast mounted sight camera. The command for this flows from the pilot command processor **2** into the mission avionics graphics generator **4**. The mission avionics graphics generator switches to the video images from the mast mounted sight video and these images are then transmitted to the digitize and video image apparatus **18** which was signaled to receive and display these signals through the mission avionics data link control apparatus **10**. The analog video signal is digitized to include any overlaid data and then converted to video form before the video images are rendered on the multi-function display **139**. At this point the pilot, through the pilot command processor **2**, can direct the mission avionics data link control **10**, to activate the capture video subfunction **135** with a command to the digitize and control video image apparatus **18**. Once the image displayed on the multi-function display **139** is captured the pilot may, through different mechanisms in the cockpit, annotate the image. These annotation commands come through the mission avionics data link control **10** on to the global bus **5**, and the image is then annotated through the data signal processing apparatus **20**. Once the video image has been annotated, it can be compressed and formatted for either transmitting externally through the transmit/receive digitized data medium **138** from the data signal processing apparatus, or storing in memory (MDU) **3**.

When the pilot transmits information externally, a command signal is sent through the mission avionics data link control **10** to the setup and control of transmit/receive medium apparatus **16** in order to configure the transmit/receive digitized data medium **138** to transmit image information. As described above, the transmit/receive digitized data medium **138** transmits either directly to a radio or to a radio via a digital modem. If the pilot wishes to transmit stored information, a command through the mission avionics data link control **10** to the data signal processing apparatus **20** retrieves the information from MDU **3** via the image data storage and retrieval interface apparatus **135**. This information is encoded with error correction by the error correction apparatus **132** and then received by the data signal processing apparatus **20** for packaging. Depending on the chosen mode of operation for the datalink, the medium is configured accordingly and the information with a customized format is transmitted externally.

In the situation where the aircraft receives video, mission update, or situation awareness data externally, this information is first received through the transmit/receive digitized data medium **138**. As described above, this medium is configured to receive the digitized image data that is being transmitted by an external source. From the medium, the information is transferred to the data signal processing apparatus **20**. Once the signal processing means identifies the type of data received, the prioritization and authentication apparatus **14** is activated. Authentic image data received externally is encoded to validate mission ID and aircraft ID. Once authenticated, the data is then prioritized according to the type of mission the aircraft is on, aircraft identification, and the type of information contained in image file. Based on the priority assigned, a determination is made for each received image file as to whether to present to the pilot, to eliminate, or store away. When received image file has an acceptable priority, its error correction is removed at **132** and the compressed image file is stored in **3**.

When an aircraft is flying a mission, certain types of information are more important to a pilot successfully completing the mission than others. The present invention

includes a prioritization scheme which prioritizes the type of data received based on its content. For example, mission data containing video of engagement scenes and armament status or situation awareness data from a coordinate airplane are of greater importance and have a higher priority than regular map video images being transmitted by another aircraft. As such, this situation awareness data is immediately provided to the situation awareness overlay data apparatus **8** for inclusion on any of the images generated by the moving map generator **6**. If the image data which is received is of low priority, the data signal processing apparatus **20** will assign an image header and store it in MDU **3**. The pilot then may later retrieve this information for view or re-transmit.

All images which are stored in memory **3** are in a digital compressed form. If the pilot wishes to retrieve and view an image stored in memory, a command is first sent to the mission avionics data link control **10** which then through the data signal processing apparatus **20** retrieves the image from memory **3**. The image is converted to a digital bitmap by data decompression/compression apparatus **131** and transmitted via the high speed data bus to digitize and control video image apparatus **18** which then converts the retrieved image from a digital bitmap to an analog video signal. This analog video signal is then transmitted to the MFD **139** for viewing by the pilot. As the image is being viewed, the pilot may annotate and then re-capture the image with subfunction **135**. Through commands to the image data annotation apparatus **12** and the mission avionics graphics generator **4**, from the pilot, the annotation process is completed. This annotated video image may then be converted back to a digital map which is then either put in memory **3** or transmitted externally via the data signal processing apparatus **20**.

When mission update information is received from an external source, it is first identified by the data signal processing apparatus **20** and then authenticated via the prioritization and authentication apparatus **14**. Once authenticated and otherwise decompressed and error corrections removed, it is transmitted via the global bus **5** based on its content to either the flight plan update and activate apparatus **110**, the battlefield graphics update and activate **111**, the target update and activate apparatus **112**, the prepoint update and activate apparatus **113**, or the communications update and activate apparatus **114**. When this information is received, an advisory message to the pilot will appear on the screen of the MED **139** in the cockpit as to whether the pilot wishes to update this information or to, at least for the time being, ignore it. If the pilot wishes to update the mission information, the update is made to the active on-board database and will instantly affect the graphics presentation of newly activated flight plan, battle field graphics, targets which appear to the pilot on the MFD. For example, if the target is updated, this will appear on the images generated by either the moving map generator **6** or the mission avionics graphics generator **4**.

If the pilot wishes to either delete images or whole data lists which are stored in memory, the pilot sends a command via the mission avionics data link control apparatus **10** to display the current image list on the MFD **139**. The pilot may then select to either delete the entire list or the particular image, and the memory is automatically packed and the image list is updated. If the pilot wishes to increase image contrast or reduce the transmit time, the pilot sends a command via the mission avionics data link control apparatus **10** to the data signal processing apparatus **20** to either increase or decrease compression index.

Finally, in the situation where the pilot receives video images from an external source, the video images are transmitted via the transmit/receive digitized data medium **138** to the data signal processing apparatus **20**. If the pilot does select to view any received images, this image file is decompressed by **131** and transmitted via the high speed data bus to the digitize and control video image apparatus **118**, which then converts the bitmap to an analog video signal which is then transmitted to the MFD **139** for viewing. At this point the pilot may wish to annotate it, and then recapture the display image. Once this process is done, the digitize and control video image apparatus **18** then converts the annotated video image back to a digital bitmap and transmits it via the high speed data bus to the data signal processing apparatus **20**. At this point, the data is then compressed via the data decompression/compression apparatus **131** and stored in memory **3**. Subsequently, the pilot may retrieve the image for viewing or externally transmitting.

The foregoing is a novel and non-obvious embedded mission avionics data link system. The applicant does not intend to limit the invention through the foregoing description, but instead define the invention through the claims appended hereto.

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. A mission avionics datalink system located onboard a vehicle comprising:

communication means which provides two way digitized data communications for the vehicle in a plurality of modes of operation;

data signal processing means in connection with the communications means which identifies information received externally by the vehicle through the communications means, and provides information generated internally by the vehicle systems to the communications means to be transmitted externally and to be transmitted internally to an appropriate component of the vehicle systems, the internal and external information comprising a plurality of mixed modes of data including external video date;

a datalink control means which recognizes and directs the processing of the information received externally and the information generated internally by the vehicle systems within the datalink system according to the plurality of mixed modes of data, said datalink control means being able to re-configure the mission avionics datalink system depending on the information processed, said datalink control means being configured to communicate with at least one other vehicle within the datalink system;

a prioritization means connected with the data signal processing means which prioritizes the internal and external information according to the type of mission the vehicle is on and information content and which authenticates the external information to ensure the external information is obtained from a legitimate source for use in operating on system parameters;

memory means to store the internal and external information;

display means to process the internal and external information and display to pilot of the vehicle; and

annotation means to allow the pilot of the vehicle to simultaneously receive the internal and external information, including avionics and mission data, and to annotate the displayed information and either store

or transmit the annotated display information externally the annotated display information being correlated with a unique parameter data set that characterizes the internal and external information.

2. The mission avionics datalink system of claim 1 wherein the data signal processing means includes means to compress and decompress the information.

3. The mission avionics datalink system of claim 1 wherein the data signal processing means includes means to correct errors in the information.

4. The mission avionics datalink system of claim 1 wherein the data signal processing means includes means to filter the information externally received.

5. The mission avionics datalink system of claim 1 wherein the datalink control means includes a pilot command processor which processes pilot input commands to determine an overall system state and sends process activation and control commands to a datalink control apparatus which then directs operations of the datalink according to the pilot commands and pre-programmed mission data included in the control apparatus.

6. The mission avionics datalink system of claim 1 wherein the prioritization means also includes an authentication means which decrypts and checks authenticity of the information from an external source and encrypts the internal information for transmission outside the vehicle, the decrypted information being used by the datalink system in conjunction with said annotation means to operate on system parameters.

7. The mission avionics datalink system of claim 1 wherein the annotation means receives inputs from avionics and mission data systems and include such inputs with the annotated display information.

8. The mission avionics datalink system of claim 1 wherein the communication means includes a radio and digital modem that can communicate in either a direct link mode or an indirect link mode.

9. The mission avionics datalink system of claim 8 wherein the communication includes a set-up and control apparatus which configures the radio and digital modem to either receive or transmit the information.

10. The mission avionics datalink system of claim 1 wherein the display means includes a mission avionics graphics generator which generates display page for viewing by the pilot in response to a plurality of inputs.

11. The mission avionics datalink system of claim 10 wherein the plurality of input includes mast mounted sight video.

12. The mission avionics datalink system of claim 10 wherein the plurality of inputs include mission avionics updates.

13. The mission avionics datalink system of claim 10 wherein the plurality of inputs includes a moving map generator.

14. The mission avionics datalink system of claim 13 wherein the input of the moving map generator includes icon symbology to generate awareness data.

15. The mission avionics data links system of claim 13 where in the selection of situation awareness icon symbology includes pop-up pipe-line of selective situation awareness data.

16. The mission avionics datalink system of claim 1 wherein the display means includes a mission avionics graphics generator video switch to continuously build coherent video image from different video sources.

17. The mission avionics datalink system of claim 16, wherein the coherent video image from different video sources are either stored internally or transmitted externally.

18. The mission avionics datalink system of claim 16, wherein the mission avionics graphics generator video switch works in conjunction with said annotation means.

19. A data link system located onboard an aircraft comprising:

a transmit/receive data medium to contact data sources external to the aircraft, which transmits and receives in a plurality of modes of operation;

a signal processing apparatus connected to the medium to identify and convert internal and external data which is transmitted and received through the medium for transmission to an appropriate component of the aircraft's systems, the internal data and external data comprising a plurality of mixed modes of data including external video data;

prioritization and authorization means which checks authorization on the data received by the medium and determines the priority of the received data according to a pre-defined standard where high priority data is retained to be displayed and low priority data is stored in a memory, the prioritization and authentication means authenticating the data to ensure the data is obtained from a legitimate source for use in operating on system parameters;

a mission avionics graphics generator which receives a plurality of inputs from the aircraft systems and provides graphics information for transmittal externally by the medium or for viewing by the pilot;

digitized and controlled video image means which receives graphics information from said processing means and said mission avionics graphics generator and converts said information to image form for display or digitizes the information for storage in the memory or transmission from the aircraft;

a data link control means which translates commands from the pilot to determine which mode the medium will operate, what information will be displayed to the pilot, and what data will be transmitted from the aircraft, said datalink control means being configured to communicate with at least one other vehicle within the data link system; and

annotation means to allow the pilot of the aircraft to simultaneously receive the internal and external data, including avionics and mission data, and to annotate the displayed data and either store or transmit the annotated display data externally, the annotated display data being correlated with a unique parameter data set that characterizes the internal and external data.

20. The data link system of claim 19 further comprising means to improve image quality and contrast.

21. The data link system of claim 19 further comprising means to optimize the receive and transmit time for transmit/receive medium while operating in a direct link or indirect link mode.

22. The data link system of claim 19 further comprising means to continuous capture and send of motion image in real-time.

23. The data link system of claim 19 further comprising means to continuous receive and render of motion image in real-time.

24. The data link system of claim 19 further comprising means to view any image stored in the memory.

25. The data link system of claim 19 further comprising means to manage and recall all images stored in the memory, wherein the images stored were previously stored depending on the priority assigned by the prioritization and authorization means.

26. The data link system of claim 19 further comprising means to automatically request and respond to requests for situation awareness data.

27. The data link system of claim 19 further comprising means to filter all image data received.

28. The data link system of claim 19 wherein a map generator is connected to the mission avionics graphics generator in order to provide map information for display to the pilot.

29. The data link system of claim 28 wherein means are connected with the image data signal processing means to receive outside mission information and update the mission information in the map generator.

30. The data link system of claim 19 wherein said annotation means annotates the graphical information with words as an overlay on an image.

31. The data link system of claim 30 wherein the means to annotate graphical information includes means to annotate precision data, free text, and video images.

32. The data link system of claim 31 further comprising means to command and generate video annotation to overlay displayed images.

* * * * *

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United States Patent [19]

Oder et al.

[11] Patent Number: 5,475,594

[45] Date of Patent: Dec. 12, 1995

[54] **METHOD AND DEVICE FOR ASSISTING THE PILOTING OF AN AIRCRAFT FROM A VOLUMINOUS SET OF MEMORY-STORED DOCUMENTS**

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[73] Assignee: **Sextant Avionique**, Meudon La Foret, France

[21] Appl. No.: **95,710**

[22] Filed: **Jul. 23, 1993**

[30] **Foreign Application Priority Data**

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Jul. 24, 1992 [FR] France 92 09415

[51] **Int. Cl.**[6] **G06F 17/30**; G06F 3/14

[52] **U.S. Cl.** **364/424.06**; 340/971; 395/161

[58] **Field of Search** 364/424.06, 443, 364/444; 340/971; 395/600, 155, 156, 160, 161

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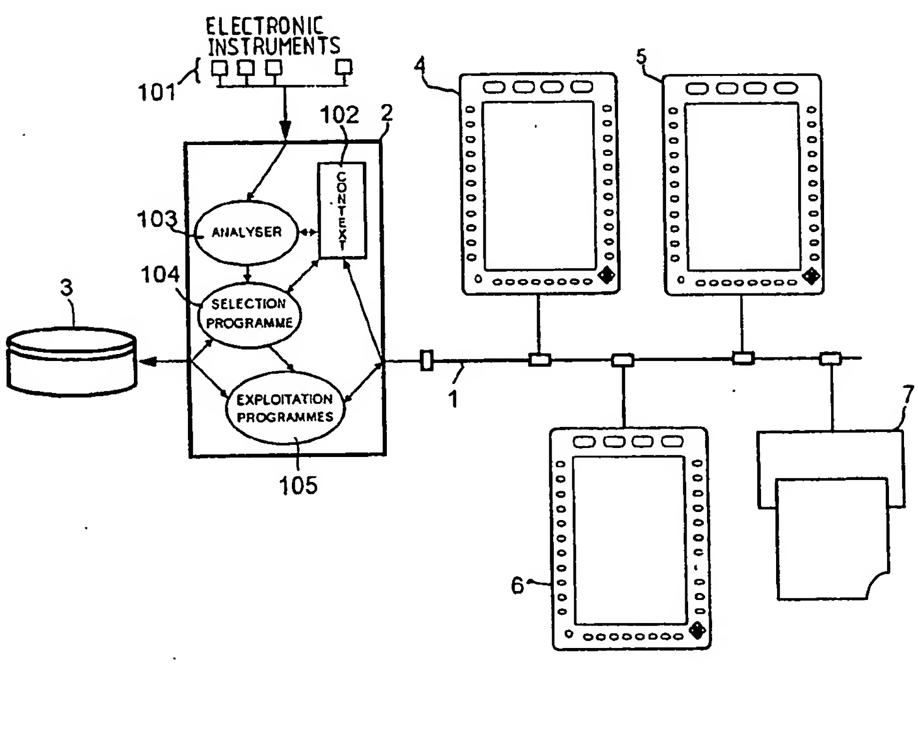
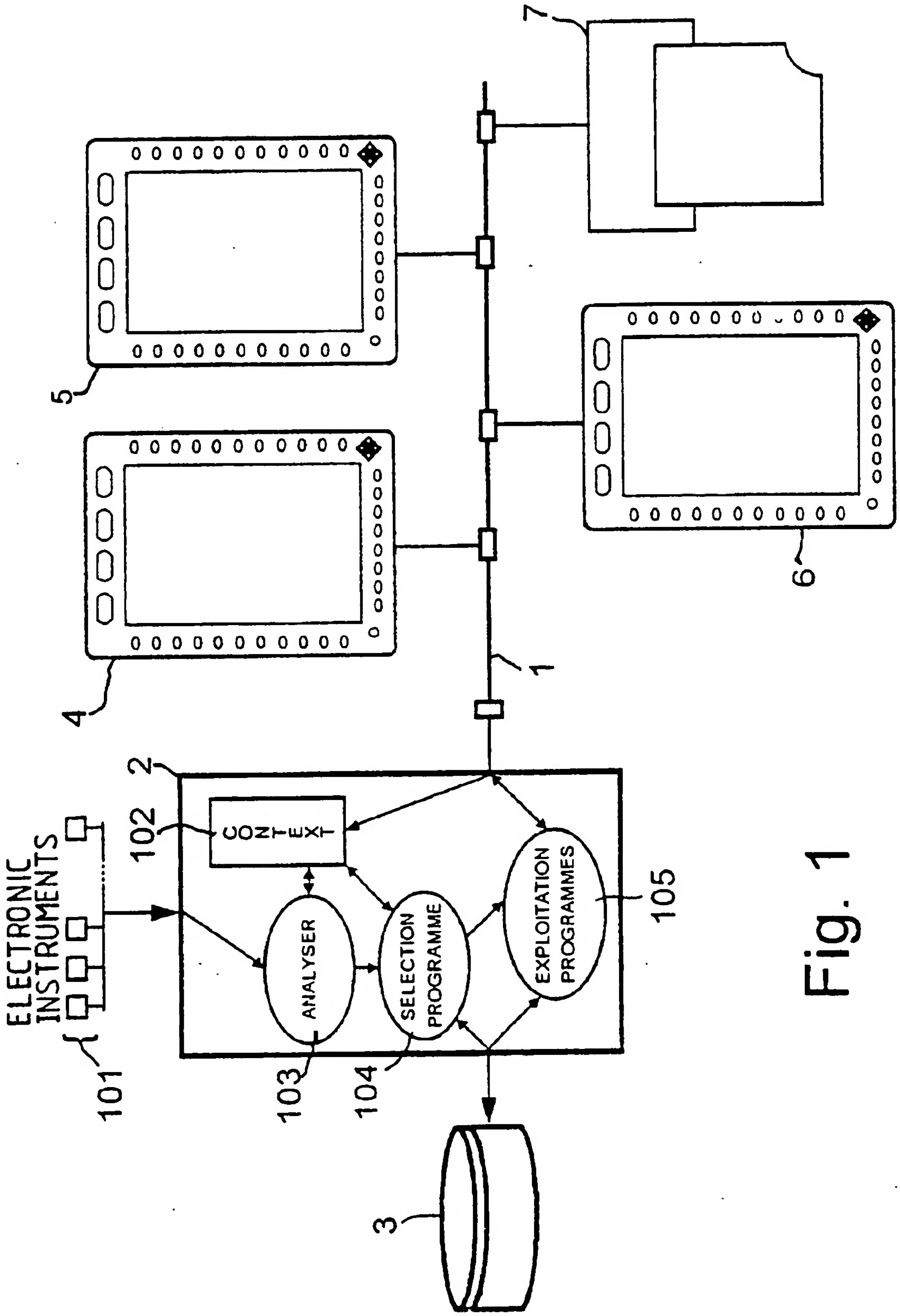
Primary Examiner—Michael Zanelli
Attorney, Agent, or Firm—Browdy and Neimark

[57] **ABSTRACT**

A method for assisting the piloting of an aircraft from a voluminous set of memory-stored documents which uses a processor associated with a terminal comprising a screen and control and data entry keys and with memories containing useful information for operating a flight, the processor being connected to other items of equipment of the aerodyne. The method comprises storing of information in a data base and supplying first exploitation functions of this information, real-time acquisition by the processor of an event relative to the current situation of the aerodyne and analyzing the new situation generated by the occurrence of this event, preselecting the information in the data base best adapted to the new situation, and classifying same by order of relevance, supplying second exploitation functions of the preselected information, selection and exploitation, by the operator, of one of the exploitation functions. The method applies in particular to the civil and commercial aviation.

25 Claims, 9 Drawing Sheets




ELECTRONIC INSTRUMENTS
101
102
CONTEXT
2
ANALYSER
SELECTION PROGRAMME
EXPLOITATION PROGRAMMES
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104
105
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Fig. 1

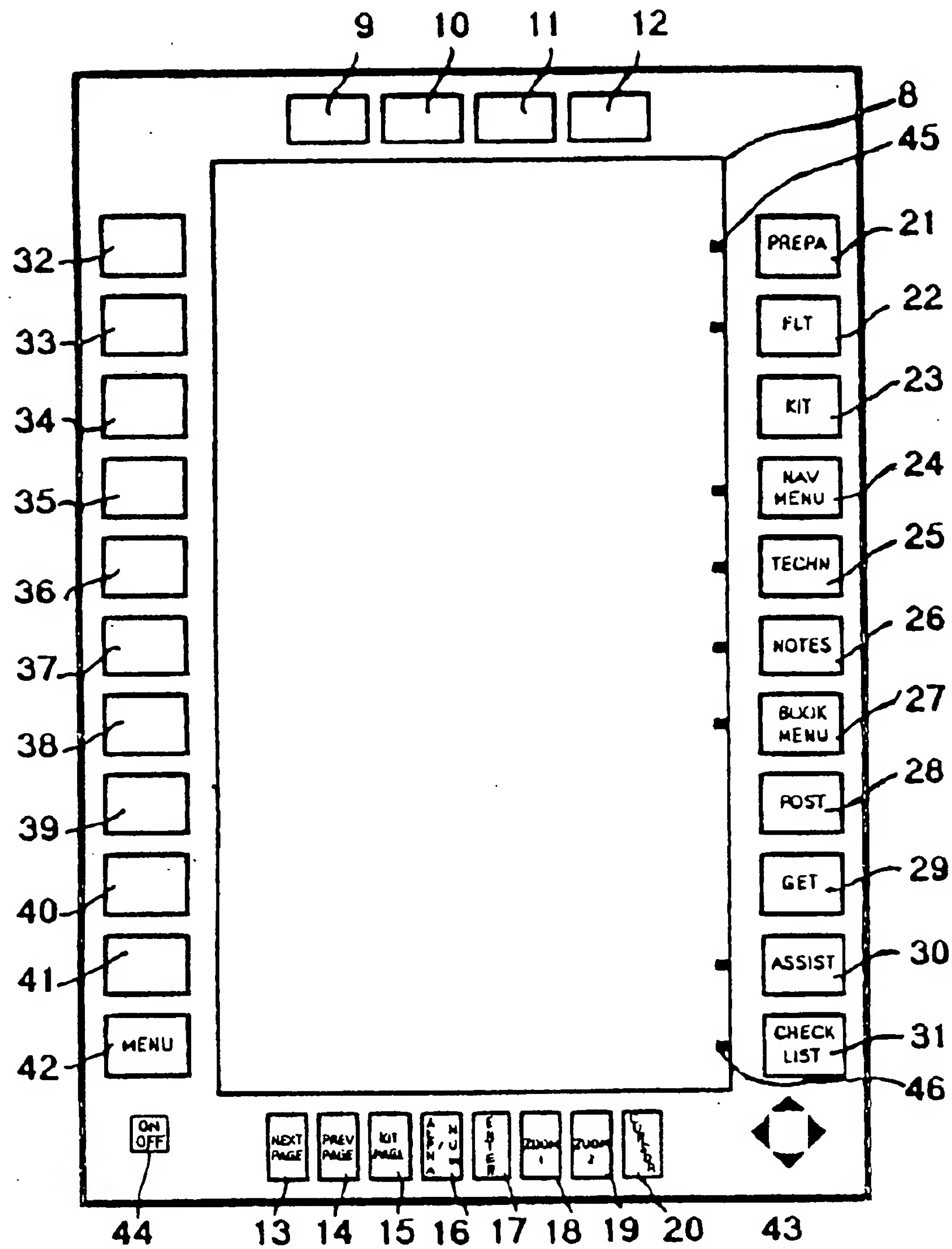
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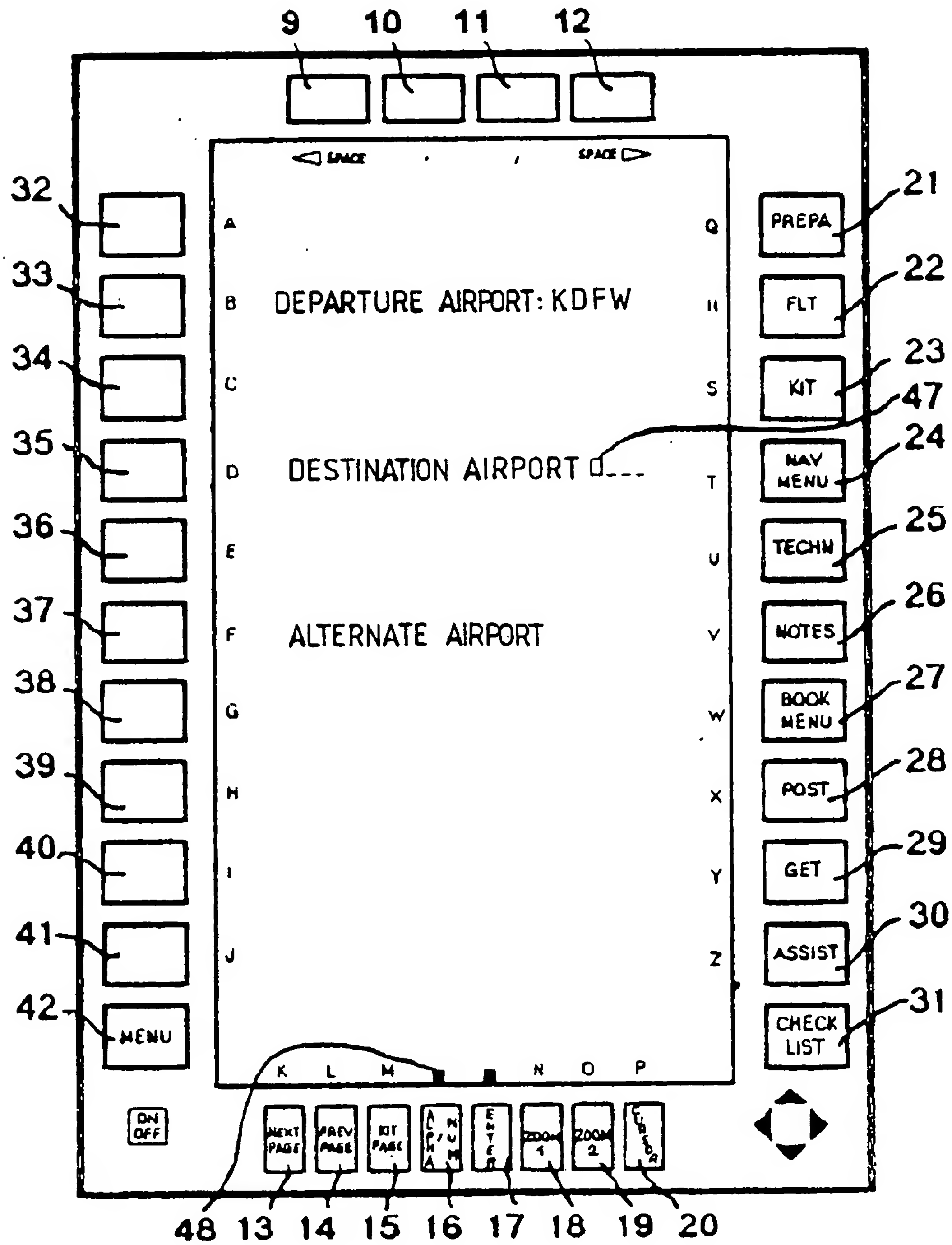
Fig. 2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SPACE
SPACE
DEPARTURE AIRPORT: KDFW
DESTINATION AIRPORT
ALTERNATE AIRPORT
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E
F
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Fig .3

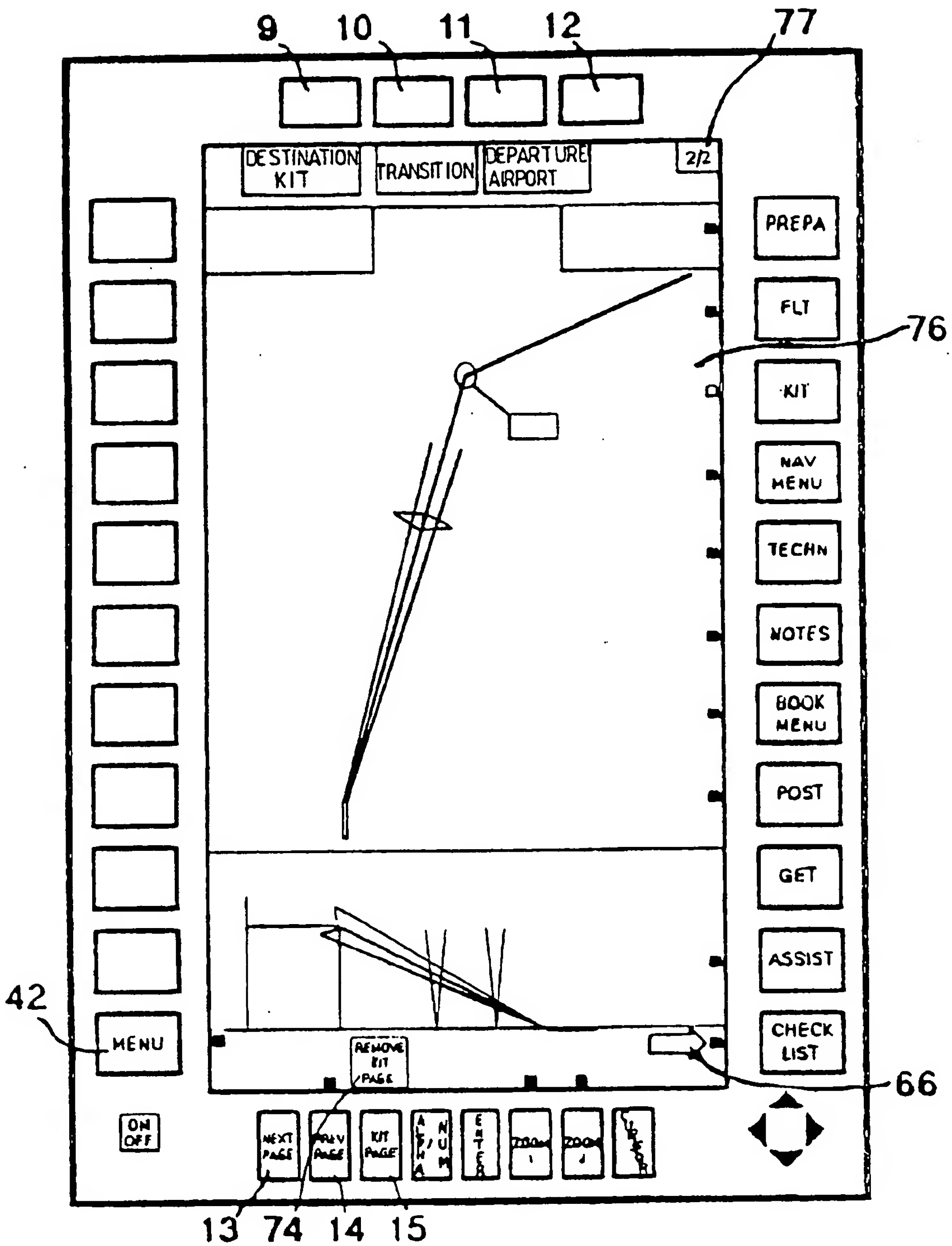
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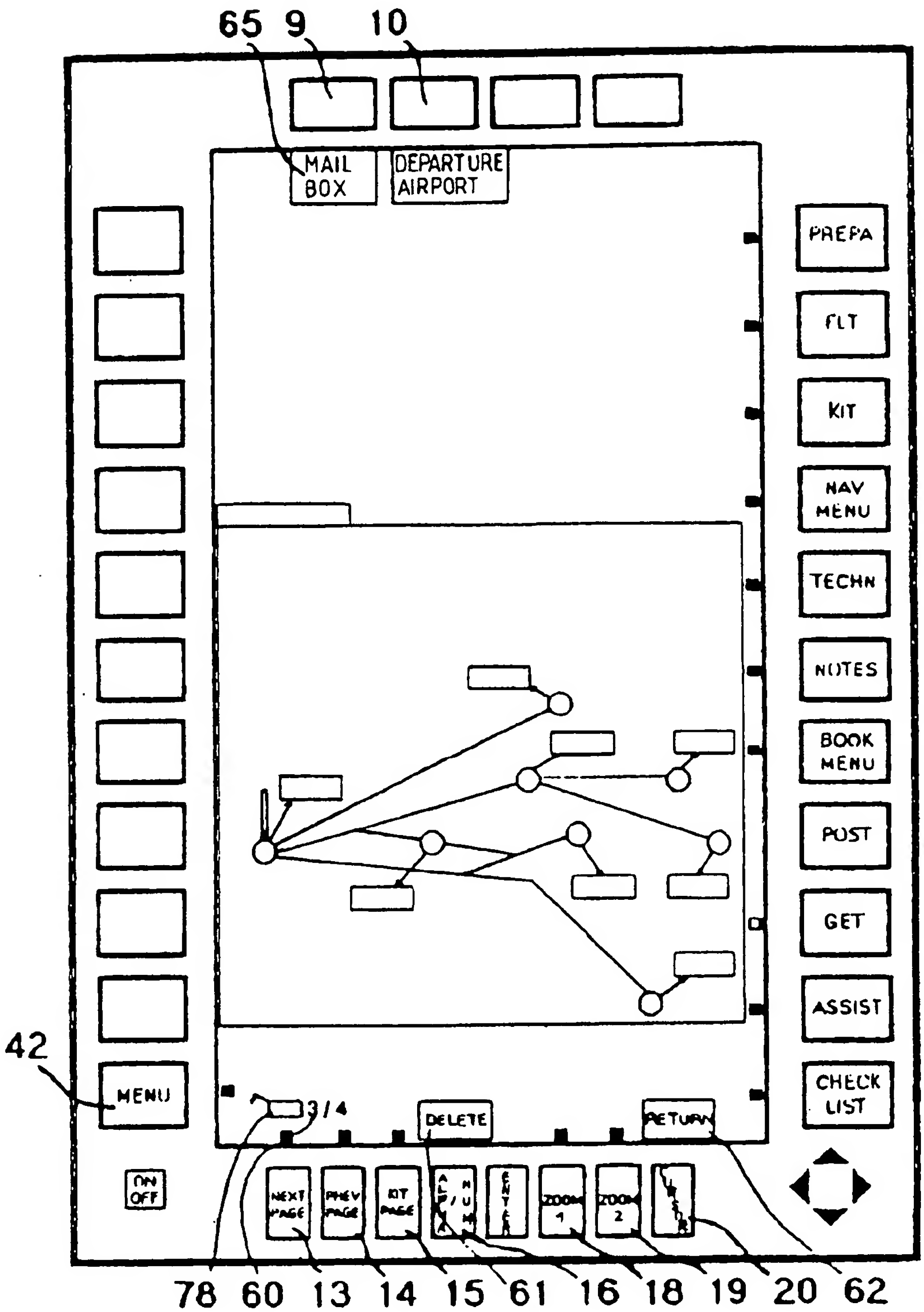
Fig. 4



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MAIL BOX
DEPARTURE AIRPORT
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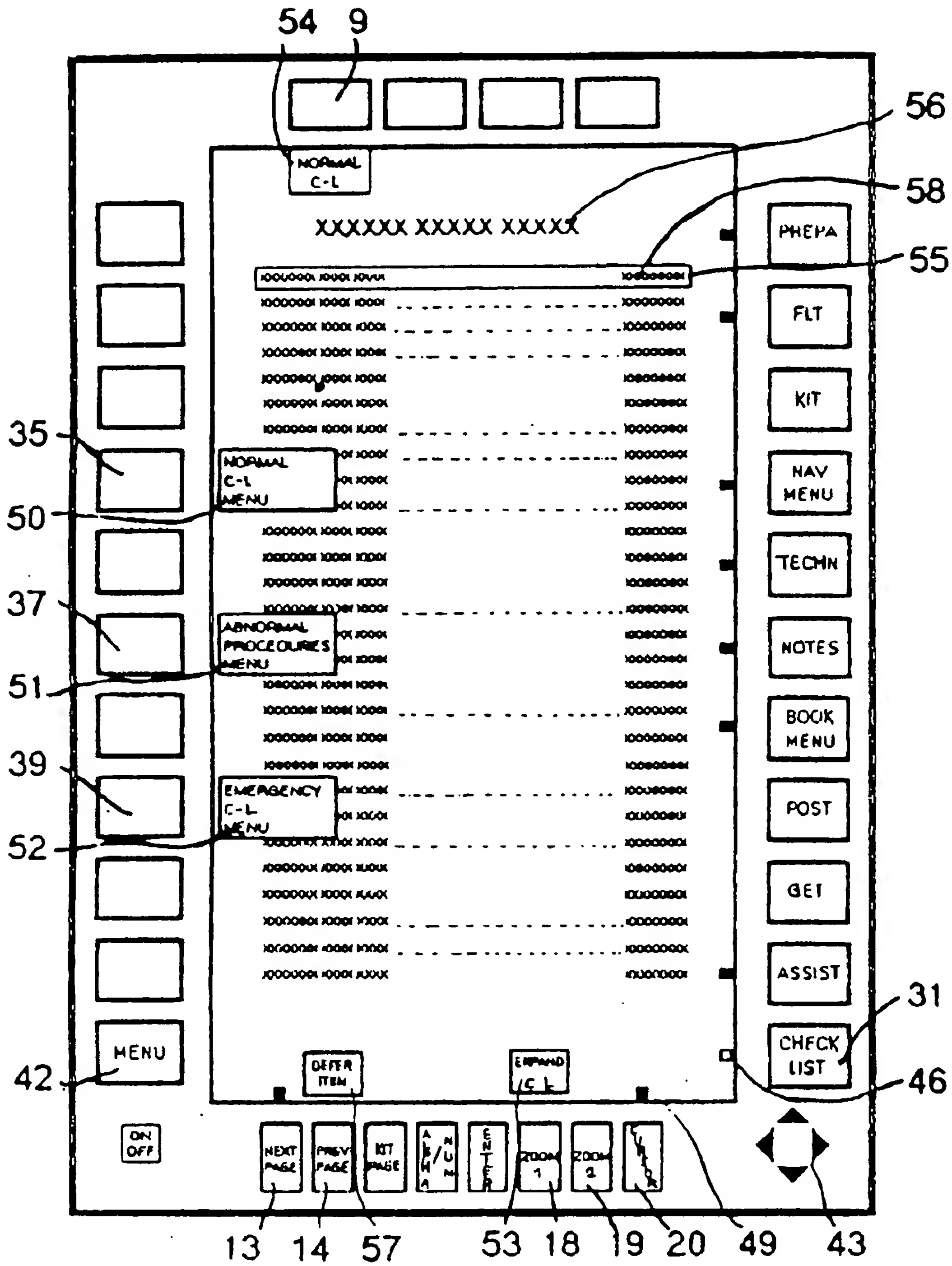
Fig. 5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NORMAL C-L MENU
ABNORMAL PROCEDURES MENU
EMERGENCY C-L MENU
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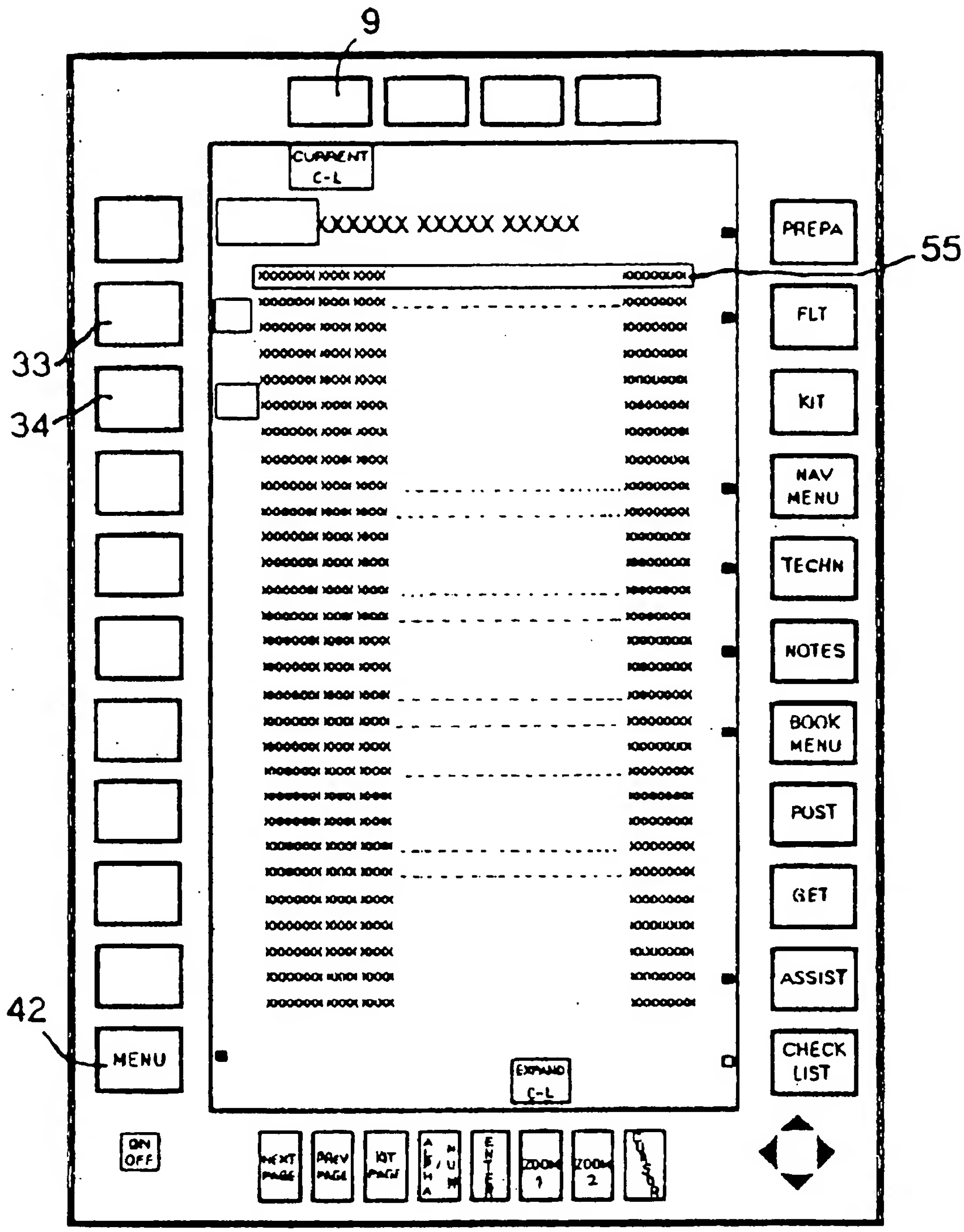
Fig. 6


9
CURRENT C-L
XXXXXX XXXXX XXXXX
PREPA
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BOOK MENU
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ZOOM 1
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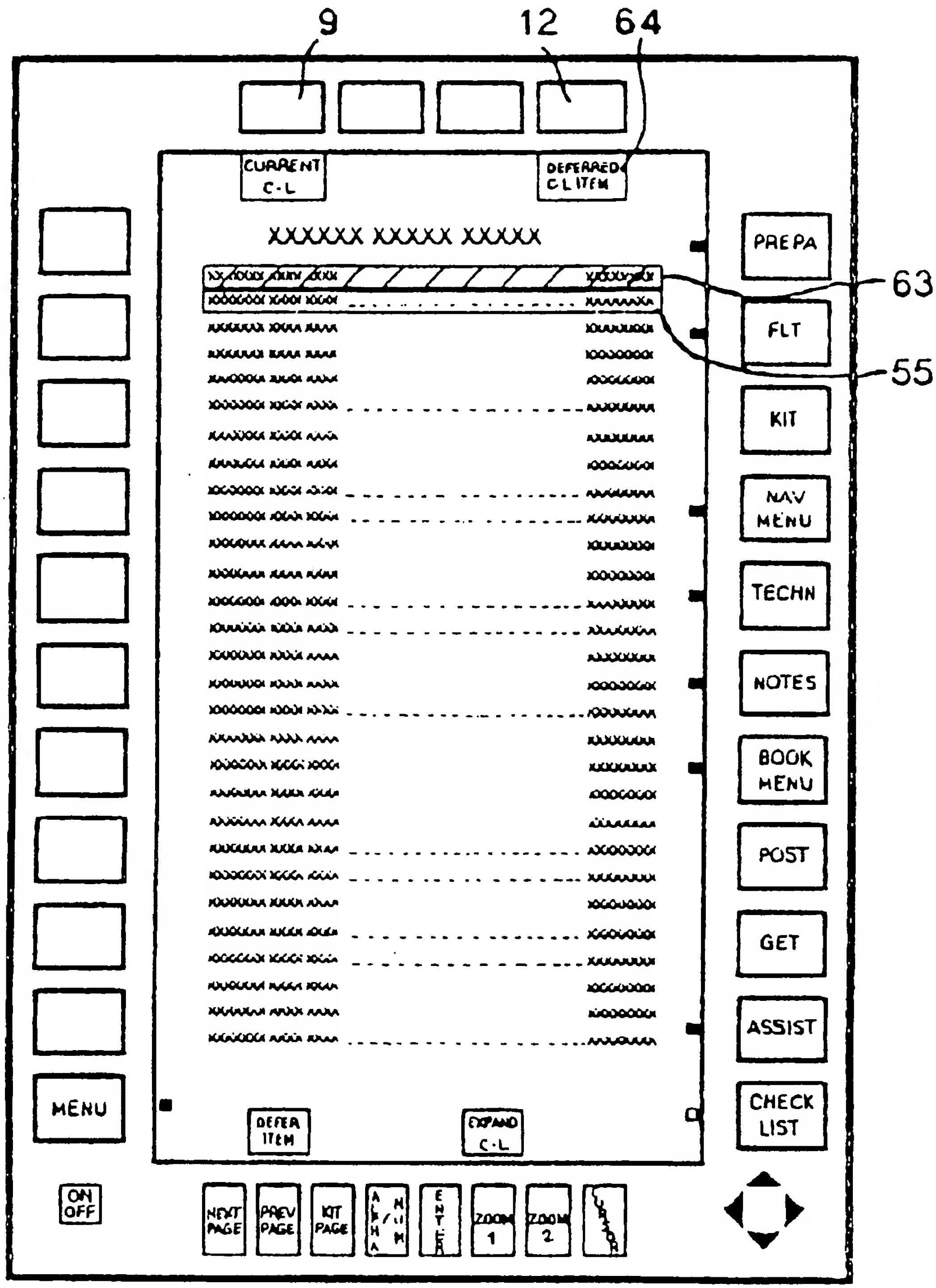
Fig. 7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CURRENT C-L
DEFERRED C-L ITEM
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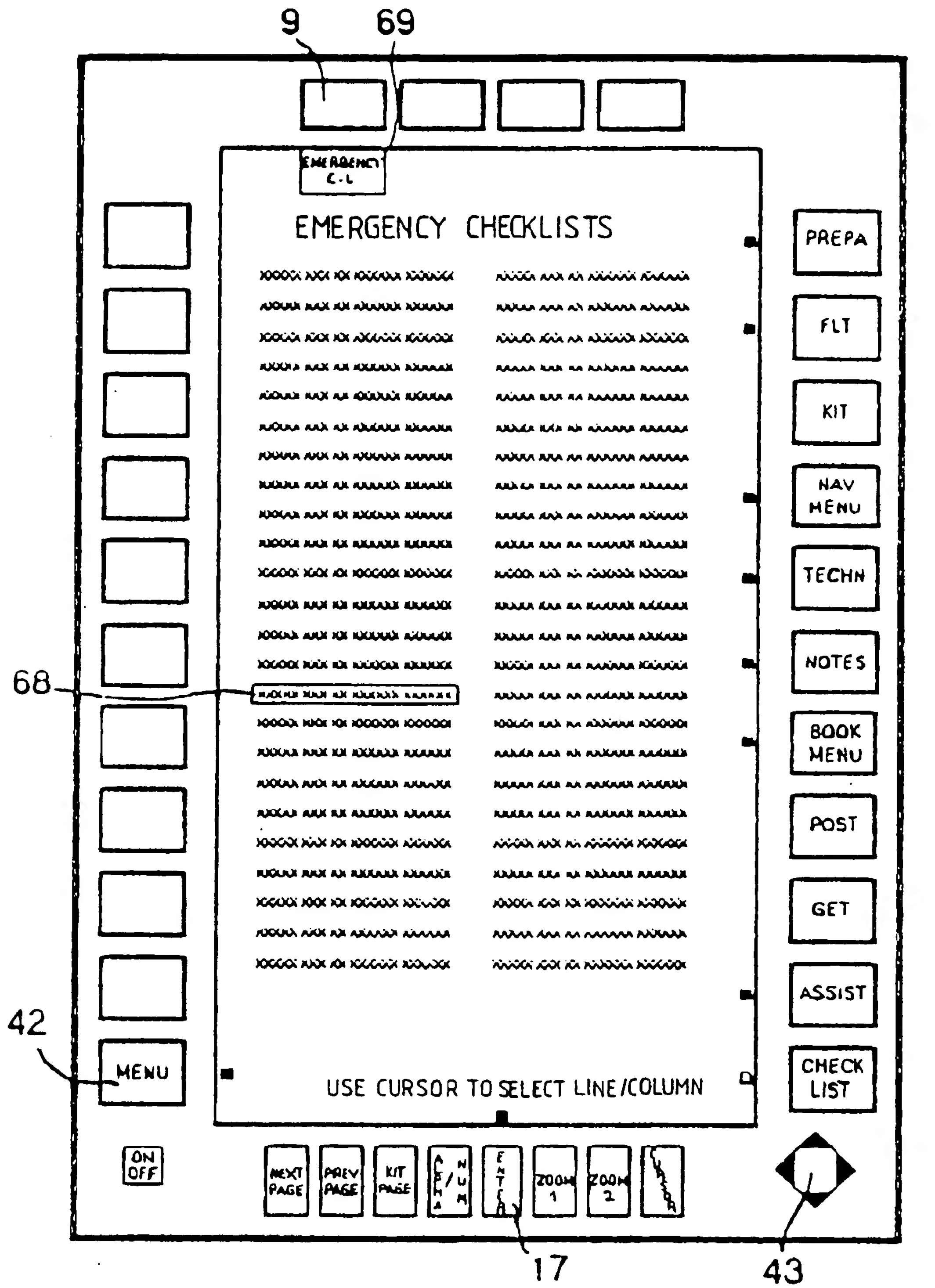
Fig. 8



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69
EMERGENCY C.L
EMERGENCY CHECKLISTS
PREPA
FLT
KIT
NAV MENU
TECHN
NOTES
BOOK MENU
POST
GET
ASSIST
CHECK LIST
68
42
MENU
USE CURSOR TO SELECT LINE/COLUMN
ON OFF
NEXT PAGE
PREV PAGE
KIT PAGE
ZOOM 1
ZOOM 2
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43

Fig. 9

METHOD AND DEVICE FOR ASSISTING THE PILOTING OF AN AIRCRAFT FROM A VOLUMINOUS SET OF MEMORY-STORED DOCUMENTS

FIELD OF THE INVENTION

The present invention concerns a method and a device for assisting the piloting of an aerodyne from a large amount of information stored in a memory in which the information appears in the form of documents containing both texts and images.

BACKGROUND OF THE INVENTION

It is applicable in particular, but not exclusively, to civil and commercial aviation where, so as to cope with the large increase of air traffic whilst increasing the level of safety, a large number of increasingly complex and restrictive procedures and rules have been set up, both as regards each airline company and each airport. These procedures, which currently govern all the stages of a flight, are described in printed manuals able to be consulted by steering personnel at any given time.

At the current moment, this documentation is only available in printed form, represents a weight or about severals tens of kgs and is difficult to gain access to and sort out, especially on board an aircraft where the available space is relatively limited. This information concerns, for example, the various procedures to be followed during each flight stage, the data required for controlling a flight and the monitoring of the various devices of aerodynes. They originate from diverse sources, especially from aerodyne manufacturers, equipment producers, suppliers of navigation maps or even from airline companies.

For a particular situation of an aerodyne, all the information available is not strictly necessary and, the more bulky this documentation is, the longer and more difficult it is to seek out information, a situation scarcely compatible with aviation requirements.

SUMMARY OF THE INVENTION

The aim of the invention is to resolve these drawbacks and to this effect offers a method for assisting the piloting of an aerodyne implemented by a system including a processor, at least one man/machine communication terminal comprising a display screen and control and data entry keys, and memories in which in particular all the information useful for operating a flight is stored, and in particular, all the information required to conduct a flight in accordance with air regulations, the system being connected to the other electronic equipment embarked on board the aerodyne. This method is characterized in that it includes the following stages:

the entering and storing in the memories of said information in the form of a data base and, by means of the terminal, providing the operator with first means for exploiting this information;

the real time acquisition by the processor of at least one event relating to the current situation of the aerodyne and analysis of the new situation generated by the arrival of this event in the context where the aerodyne is located;

the preselection by the processor of the data base information best adapted to the new situation and their classification by order of relevancy with respect to this situation;

the terminal providing the operator with second means for processing the preselected and classified information;

the operator selecting one of said processing means and one portion of the preselected information, and

the operator exploiting on the display screen the portion of the selected information with the aid of the selected processing device.

The computer system implemented by the method is thus intended to complete existing on board computers by effectively placing at the disposal of the aircrew all the information useful for conducting the flight. This effectiveness is obtained by virtue of the preselection of information according to the context in which the aircraft is located and by means of the processing means provided by the system. This preselection is able to provide the operator with simplified fast access to the information concerned.

Furthermore, current piloting techniques call upon a large number of lists of tasks (actions - checks) informing the crew members of what tasks are to be carried out and in what order so as to enable them to act quickly and appropriately, irrespective of the situation of the aircraft, that is normal or abnormal.

These tasks are featured in printed documents in which each list is marked by a title and includes a series of wordings which each succinctly indicate a task to be carried out.

A detailed commentary corresponds to each of these lists and is featured in another document. This commentary more particularly relates to the list in general and its conditions of use, as well as to the particular features of each of the tasks of the list.

Generally speaking, the use of lists of tasks in the form of printed documents does not guarantee that all the tasks as listed have been completed, even more so when these lists are long and are sometimes interrupted by the need to carry out some other task.

Advantageously, these lists of tasks form part of the data base of the system and are thus likely to be preselected and classified. In order for these lists of tasks to be processed appropriately, the processing means implement the following stages:

following an order by the operator, the displaying on the screen of the terminal of the list of tasks preselected by the system according to the current situation of the aerodyne;

the activation of a key making it possible to position a marker which designates the first task of the list to be carried out, thus provoking the launching of processing of the list, and

the movement of said marker from one task to another following activation of a key of said terminal by the operator in order to validate the task designated by said marker when the said task has been executed and in order to have the marker designate the next task to be carried out.

According to one particular characteristic of the invention, the processing means include means to gain access to the various types of information stored in the data base in the same way as a library containing books. These means implement the following stages:

the sequential consultation of a set of information page by page;

the display on the screen of the contents and index tables of keywords in the form of menus whereby the operator is able to make a selection in order to gain instant access to the corresponding information, and

the activation of reference links between one first set of

information the operator consults on the screen and other sets of information, thus offering the operator the possibility of returning to the set of information where the start point of the link is located.

According to another particular characteristic of the invention, the processing means also include means to store when ordered by the operator the page displayed in an easily and quickly accessible space provided to this effect.

This memory space rendered accessible by a terminal thus enables the pilot in particular to collate during the flight preparation stage all the pages he frequently needs to consult rapidly, especially during the manoeuvring phases.

Thus, the invention offers a device for speedily and easily processing a large volume of information and is perfectly adapted to the tasks of seeking information when piloting a commercial airplane.

BRIEF DESCRIPTION OF THE DRAWINGS

One non-restrictive example of an implementation of the method of the invention shall now be described hereafter with reference to the accompanying drawings on which:

FIG. **1** is a diagram of the architecture of the information processing system embarked on board the aerodyne;

FIG. **2** diagrammatically shows a communication terminal;

FIGS. **3** to **9** diagrammatically show different screens chained by examples of means for processing the information stored in the data base.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The diagram appearing on FIG. **1** shows an example of the architecture of an information processing system intended to be embarked on board a commercial aircraft and implementing the method for assisting the piloting of an aerodyne.

This system is formed of a local network **1** to which the following are connected:

a central processing unit **2** managing access to the local network and to the bulk memory **3** possibly formed of several magnetic, optical or magneto-optical disk units,

communication terminals **4**, **5**, **6** adapted to usage on board a commercial aircraft and in particular inside the pilot's cockpit where the available space is relatively small, and

a printer **7** offering the operator the possibility of printing the page displayed on the screen.

The central processing unit is connected by means of buses of the aircraft to the embarked set **101** of sensors and electronic systems so as to acquire in real time the data available on the other items of equipment on board.

The bulk memory **3** is able to store in a data base form all the information normally existing in the form of printed matter in the pilot's cockpit of a commercial aircraft. For example, this information concerns:

the flight manuals,

the documentation associated with each airport of the traversed geographical zone and including in particular the description of the take-off and landing procedures,

the navigation maps and manuals of the traversed geographical zone, . . . and for each type of aircraft:

the operational manual,

the minimum equipment description manual, and

the maintenance manual.

This information is supplied according to different formats (ASCII files, digitalized images, books) and different media (data processing, paper). It is then converted according to standard formats (SGML for texts, CGM for vectorized images, and CCITT/G4 for images with the bitmap format) so as to be integrated into a data base situated on the ground from which data bases are extracted adapted to the various types of aircraft.

Before being embarked so as to be stored in the bulk memory **3**, these data bases are converted according to a predetermined format. The embarked data bases are completed by an "application" data base which lists together the various exploitation programs **105** of the data stored in these bases. These programs are designed to facilitate piloting tasks and help the crew to resolve any problems the latter may encounter.

These programs **105** constitute the translation into a data processing language of the various scenarios according to which the types of information are to be processed and chained with one another.

In particular, they define for each processing stage:

the information to be exhibited on the screen,

the way information is presented,

the active keys of the terminal and their respective functions, that is the respective programs to be executed.

The central processing unit **2** implements a program **103** known as an "analyzer" program which is activated upon the arrival of an original event, either from the environment **101** of the system or from one of the terminals **4,5,6** generated by an operator when he presses a key. The aim of this program is to analyse the events occurring so as to manage a set of variables which define the real time context **102** in which the aircraft is located. With the aim of finely analysing complex situations, it may be conceived according to an expert system comprising a knowledge base, a rule base and an inference engine.

The variables of the real time context **102** concern more particularly:

the description of the current flight (departure airport, destination and alternate airport, route),

the current flight phase,

the situation of the aircraft (position, altitude, speed),

any detected malfunctions, . . .

On each modification of the real time context **102**, the analyser **103** triggers a selection program **104** which, according to the real time context **102**, establishes the dedicated linkages between the data base information best adapted to the needs of the crew resulting from the new real time context **102** and the processing programs **105**.

When an operator triggers a processing program **105** by activating a function key of a terminal **4,5,6**, the processing program thus selected uses these dedicated linkages so as to priority-process the information best adapted to the real time context of the aircraft. Of course, the operator still has the possibility of gaining access to the other information contained in the data base.

So as to gain access to the data base, the selection **104** and processing **105** programs call upon the functions of a data base management system which may be of a standard type.

On FIG. **2**, each of the communication terminals **4,5,6** is constituted by a rectangular display screen **8** around which the keys are distributed.

Certain keys have a predetermined function and in this case, the wording of the function is featured on the key. However, these keys may be reconfigured according to the page displayed on the screen, either to activate other functions or to enter chains of characters. In this case, the name of the function allocated to each key or the corresponding character is indicated on the screen close to the key or on the key itself.

Each key may assume two or three states:

a nonactivable state when the key is not allocated to any function,

an activatable state when the key is able to activate a function, and

an active state when the predetermined function associated with the key is being executed.

Close to each key having a predetermined function, there is a state indicator **45**, **46** (shown by a square on the figures) which when lit up indicates that the key is active (in white on the figures) or activatable (in black) depending on the color of the lit up indicator and which, when out (invisible on the figures), indicates that the key is nonactivatable.

Those keys not allocated to a predetermined function may be activatable if a function wording is featured on the screen, close to the key or, if not, be nonactivatable.

The keys of the righthand column **21** to **31** are allocated to the triggering of exploitation programs **105**, as for example "PREPA" **21** for initializing a flight or "CHECK LIST" **31** for piloting assistance.

The keys **32** to **41** of the lefthand column generally make it possible to proceed with selections when menus are displayed on the screen. The last key of the left column entitled "MENU" **42** makes it possible to display the last menu which has allowed access to be gained to the current page. This key may be activated several times in a row. In this case, the various menus chained to gain access to the current page are successively displayed up to the first menu of the corresponding main function.

The keys **13** to **20** of the row below the screen make it possible to activate the functions linked to management of the terminal, as for example "ENTER" **17** to validate a selection or an entry, or "CURSOR" **20** to display and activate a cursor.

The four keys **9** to **12** located above the screen indicate consecutively the names of the four last tasks carried out by the operator. Contrarily to the "MENU" key **42**, these tasks may correspond to different main functions.

Thus, the terminal offers two different possibilities for scrolling up a chaining of selections made by the operator: the keys **9** to **12** situated above the screen make it possible to chronologically scroll up this chaining by granting access to the last three sequences used, whereas the key "MENU" **42** makes it possible to scroll up a menu chaining tree structure.

One of the exploitation programs makes it possible to control the initialization phase of a flight, the aim of this program being in particular to initialize the context of the flight. This program is activated by means of the key "PREPA" **21**. This key is able to trigger the display of the screen shown on FIG. **3** on which the departure airport code appears ("DEPARTURE AIRPORT: K D F W") theoretically already known to the system since it corresponds to the destination airport of the preceding flight. The line displayed below makes it possible to enter the destination airport code in a maximum of four letters:

"DESTINATION AIRPORT: "- - - -".

A cursor **47** flashes on the first character to be entered in. This entry is required to define a flight as it makes it possible to define, along with the reference of the departure airport, the trajectory of the flight to be followed. On this screen, most of the keys are reconfigured so that each of them corresponds to one character of the alphabet, thus enabling the operator to key-in this code. To this effect, the character corresponding to each key appears on the display screen close to the key. The key "ALPHA/NUM" **16** appears as activatable, a black square **48** being displayed by the side of the key. This key makes it possible to reconfigure the keys so as to be able to key-in figures. This key **16** acts in the way of a see-saw for moving from one alphabetical entry mode to a digital entry mode and vice versa.

In these entry modes, the activation of the key "ENTER" **17**, which appears activatable, makes it possible to validate the entry. Once the entry is validated by the key "ENTER", the system shall look in its memory to see if the airport code entered exists. If it does not exist, an error message is displayed by the system and the cursor is positioned on the first character to be keyed in. If it does exist, the cursor moves to the field to be entered next which concerns the alternate airport:

"ALTERNATE AIRPORT: - - - -".

This entry is optional and when the operator has pressed the key "ENTER" **17**, the central processing unit **2** suppresses the allocation of keys to the entry and renders activable the three keys **33**,**35**,**37** of the lefthand column situated at the level of the three lines where the flight airport codes selected are displayed. These keys make it possible to select an airport so as to display the documentation concerning said airport.

As the flight preparation function is being processed, the indicator **45** associated with the key "PREPA" **21** shows that the key is active. In addition, the key **41** entitled "MODIFY AN AIRPORT", also rendered activatable, makes it possible in an analog way to modify the entry previously made.

As mentioned previously, the system is connected to the other items of the electronic equipment of the aircraft so as to detect in particular the take-off of the aircraft and thus prohibit modifying the departure airport after take-off.

If one of the keys **31**,**33**,**35** is activated to select an airport, a list of documents concerning the airport thus designated appears on the screen in association with the keys **32** to **41** of the lefthand column. These documents are selected from the documentation stored in the data base according to the type of airport, that is the departure, destination or alternate airport. Thus, for example, the arrival instructions are not necessary when the operator asks for the documentation of the departure airport. On the other hand, the key **9** takes the designation of the selected sequence. It is entitled for example as the "DEPARTURE AIRPORT" if the operator has activated the "departure" sequence with the aim of consulting the documentation concerning the departure airport.

So as to select a document, it suffices to merely press the key of the lefthand column situated at the level of the line where the title of the document is displayed. From this moment, the first page of the selected document is displayed on the screen and the wording of the first key **9** of the line situated above the screen corresponds to the title of the selected document, whereas the second key **10** takes the wording the key **9** had before the operator has selected a document, that is for example the "DEPARTURE AIRPORT". By pressing on this last key **10**, the operator is able

to again display the list of documents concerning the selected airport so as to display another document.

The operator can also fully display the document he has selected by means of the keys "NEXT PAGE" 13 and "PREV PAGE" 14 which enable him to respectively display the following and preceding pages, the various pages of a document being shown by order of importance in the context of the current flight.

At this stage, the preparation of the flight consists of selecting a set of important pages so as to memorize them and thus be able to gain fast access page by page by means of a single key. To this effect, the information processing system described earlier also includes a memory space enabling the operator to store screen pages.

This memory space includes four subdivisions corresponding to various requirements, the first three being respectively allocated to the airports of the flight, namely:

the "departure" subdivision concerning the departure airport,

the "destination" subdivision concerning the destination airport,

the "alternate" subdivision concerning the alternate airport,

the "free" subdivision concerning all the other documents.

All these subdivisions are unique, even if the system comprises several terminals, except for the "free" subdivision which is specific to each terminal. In this way, the information stored in the subdivisions concerning the airports of the flight is accessible by all the terminals of the system, whereas each terminal has its own "free" subdivision to which it is the only one to have access.

The insertion function key of a page in this memory space is solely activatable when the page displayed may be inserted in one of these subdivisions. Only the first three subdivisions are structured according to the documentation associated with the flight airports.

Any page may be inserted in the "free" subdivision, except for pages corresponding to the first three subdivisions.

Conversely, only the pages corresponding to an airport of the flight can be inserted into one of the first three subvdivisions.

So as to record a page displayed on the screen in one of these subdivisions, it suffices to merely press the key "KIT PAGE" 15 and the system determines in what subdivision the page is to be memorized according to the current sequence, provided the key in question is activatable. For example, if the pilot has activated the sequence "departure" to display the current page and if he presses the activatable key "KIT PAGE" 15, the current page is stored in the "departure" subdivision. During the two seconds following activation of the key, the next message is displayed at the bottom of the screen so as to inform the operator that his order has been properly taken into account: "PAGE 1 STORED IN THE DEPARTURE KIT" if this concerns the first page stored in the "departure" subdivision.

So as to prevent the operator from twice inserting the same page in a subdivision, the function of the key "KIT PAGE" 15 is reconfigured into "REMOVE KIT PAGE" 54 so as to suppress the page which has just been inserted. This key 15 shall reassume its "KIT PAGE" main function for page storage during the displaying of a page which has not already been stored in a subdivision.

If the key "KIT PAGE" 15 is activatable and none of the three sequences corresponding to the first three subdivisions allocated to the airports of the flight is active, the current page shall be stored in the "free" subdivision.

There is no limit to the number of pages stored in a subdivision, but the higher this number is, the less is the advantage of this function as it shall then pose a problem for selecting the sought-after page.

The pages are automatically sequenced in the subdivisions according to their importance which is defined as regards the order in which the documents and pages inside a document are classified in the data base.

So as to gain access to one of these subdivisions, it merely suffices to press the key "KIT" 23 situated in the righthand column of the screen. If only a single subdivision has been filled, access can be effected directly to this subdivision. Otherwise, that is if at least two subdivisions are filled, a menu having available subdivisions associated with one portion of the keys 32 to 41 of the lefthand column enables a subdivision to be selected.

When the key "KIT" 23 is pressed and at least one page has been stored in a subdivision, the indicator 55 associated with this key 23 is in the active state.

The choice of a subdivision from the selection menu causes the displaying of either the page of the previously displayed subdivision or the first page of the subdivision if it has never been consulted. When a subdivision has been selected, the various pages stored there may be displayed by means of the key "NEXT PAGE" 13 so as to move to the next page, and the key "PREV. PAGE" 14 to move to the preceding page. If the first page of a subdivision is displayed, only the key "NEXT PAGE" 13 is active. Similarly, if the last page of a subdivision is displayed, only the key "PREV. PAGE" 14 is active.

FIG. 4 represents a screen obtained by displaying an approach map 76 stored in the destination subdivison as indicated by the key 9 entitled "DESTINATION KIT". The wordings of the keys 10 "TRANSITION" and 11 "DEPARTURE AIRPORT" indicate that the document entitled "TRANSITION" is being displayed concerning the departure airport at the moment the subdivision "destination" has been requested to be consulted. The key 10 makes it possible to display the page which was displayed when the operator has activated the key "KIT" 23, that is a page of the document entitled "TRANSITIONS" associated with the departure airport. The key 11 allows for gaining access again to the selection menu of an airport.

Moreover, the number of the page in the subdivision is displayed in the upper righthand corner of the screen and the number of pages stored in the subdivision "2/2" 77 indicates that the subdivision contains two stored pages and the page displayed is the second page.

When a page of a subdivision (FIG. 4) is displayed, it is also possible to delete it from the subdivision by pressing the key "KIT PAGE" 15 reconfigured into "REMOVE KIT PAGE" 74. In this screen, if the activatable key "MENU" 42 is pressed, the selection menu of the subdivisions used appears overprinted.

For a system including several terminals, it is possible to select a page on one terminal and place it in another subdivision known as a "mail box" to be placed at the disposal of the other terminals. This enables the user to prepare a document intended for another user. So as to place a document in this subdivision, it merely suffices to press the available key "POST" 28. At this moment, this key becomes active and on all the terminals of the system, the key "GET" 29 allowing for displaying the contents of this subdivision becomes activatable and a special symbol 78 appears on all

the screens (FIG. 5). The active key "POST" **28** becomes available when the page stored there is no longer displayed on the screen and nonactivatable if this page is redisplayed.

This function is particularly advantageous within the context of a crew operation when one member of said crew carries out piloting whereas another assists him in his task.

So as to display the contents of this subdivision, it merely suffices to press the key "GET" **29** which moves from the activatable to the active state. The last page inserted in this subdivision then appears on the screen, as well as the number of this page and the number of pages stored **60** (FIG. 5).

Above the screen, the first lefthand key **9** entitled "MAIL BOX" **65** indicates that the contents of the "MAIL BOX" subdivision is being displayed.

Another program makes it possible to assist the crew during the entire flight by informing it of the tasks to be carried out during each piloting stage. So as to activate this program, it merely suffices to press the key "CHECK LIST" **31** which is active or continuously activatable according to the color of its state indicator **46** associated with it (for example, on the screen of FIG. **2**).

The list of tasks of the current flight phase then appears on the screen (FIG. **6**). This is represented by a title **56** which may possibly be "PRIOR TO START UP OF ENGINES" which corresponds to the tasks to be carried out prior to engine start up. This title is followed by the wording **58** on one line of each task to be successively carried out during the current flight phase. The indicator **46** associated with the key "CHECK LIST" **31** has become active (represented by a white square) indicating that the associated function is being processed.

Three keys **35,37,39** of the lefthand column of the screen are activatable and their function, respectively **50,51,52**, appears overprinted close to these keys. They make it possible to gain access to the selection menus of the other lists, each key corresponding to a type of list, namely:

"NORMAL C-L MENU" **50** allowing for access to be gained to the other normal lists;

"ABNORMAL PROCEDURES MENU" **51** allowing for access to be gained to the abnormal procedures;

"EMERGENCY C-L MENU" **52** allowing for access to be gained to the emergency lists.

If, for example, the operator activates the key **35** when it is configured as "NORMAL C-L MENU" **50**, a new page is displayed on the screen corresponding to the first of those pages granting access to the set of normal lists whose presentation is adapted to the context in which the aircraft is located. An index making it possible to designate a list appears in the form of a frame surrounding the title of either the list being processed if it exists, or the first list. This index may be moved by means of the displacement key **43**, the four directions being activatable. When two list titles are displayed on the same line, this means that the two lists correspond to the same flight phase. In this case, the selection of one of these two lists is made by the operator or automatically by the system according to the context of the aircraft at the end of processing the preceding list.

So as to display all the titles of the normal lists, it merely suffices to press the keys "NEXT PAGE" **13** and "PREV. PAGE" **14** to respectively display the next and preceding pages. These keys are only activatable when the triggered operation is able to be executed: for example, the key "PREV. PAGE" **14** to display the preceding page is not activable if the page displayed is the first of the list.

So as to validate a selection, it merely suffices to press the activatable key "ENTER" **17** and the selected list appears on the screen. The key **9** entitled "NORMAL C-L" **62** indicates that the list of the normal lists is present on the screen. In this state, the selection menu of a type of list **50,51,52** is still accessible, but it then only grants access to the abnormal procedures **51** and the emergency lists **52**.

When the list corresponding to the current flight phase is displayed, the key "CURSOR" **20** is associated with an activatable indicator **49** and makes it possible to have appear a line index **55** represented by a frame surrounding the wording of the first task to be carried out from the list (FIG. 6). If this key is activated, the key **9** entitled "NORMAL C-L" **54** to indicate that the displayed list is a "normal" type list becomes "CURRENT C-L" so as to indicate that a list of tasks is being processed. This operation also result in the disappearance of the menu **50,51,52** which was displayed overprinted. However, it is possible to redisplay it by activating the key "MENU" **42** indicated as being activatable.

The movement of the index **55** on the various tasks of the list is ordered with the aid of the displacement key **43**, only the displacement order towards the bottom being activatable. The activation of this key makes it possible to inform the system that the task designated by the index has been completed, this having the effect of validating this task and positioning the cursor onto the next task. This is the only movement authorized for the index. Moreover, a temporization makes it possible to avoid a line skip occurring inadvertently.

This management of the cursor **55** makes it possible to guarantee that all the tasks present in a list have been executed.

The activatable key "NEXT PAGE" **13** makes it possible to gain access to firstly the continuation of the list if it has not been fully displayed, and then the next normal list. The key "CHECK LIST" **31** makes it possible to at any time display the portion of the list of tasks where the index **55** is located.

The key "ZOOM 1" **18** is reconfigured into "EXPAND C-L" **53** and makes it possible to display on another page the comments associated with the current list. If the operator presses this key "ZOOM 1" **18**, a new page is displayed on the screen comprising the title of the previously displayed list and its tasks' wordings, as well as the comments inserted between the title and the first task wording and after each wording. These comments provide additional information concerning firstly the list in general and secondly each task of the list. In this state, the operator has the possibility of displaying the next and preceding pages granting access to the set of comments associated with this list, respectively by means of the keys "NEXT PAGE" **13** and "PREV. PAGE" **14**. If the first page of the comments of the list is displayed, only the key "NEXT PAGE" **13** is activatable. The operator is also able to enlarge one portion of the screen by pressing the keys "ZOOM 1" **18** and "ZOOM 2" **19** which have become activatable. If the key **18** is activated when the list being processed is present on the screen and if all the comments of the list are not contained in a page screen, the page displayed contains as a priority the title of the list and the associated comments and then the wording of the task being processed and its comments.

The first key **9** of the upper row has then becomes "EXPANDED C-L" **59** indicating that the page displayed is a list of tasks containing comments. The activatable key

"ENTER" **17** makes it possible to go back to the preceding screen (FIG. **6**).

Generally speaking, when the index **55** designating the task currently being executed is not present on the screen, it merely suffices to activate the key "CHECK LIST" **31**. This key makes it possible to display the current list and overprint the selection menu of another type of list **50,51,52**, regardless of the page present on the screen.

When the operator has activated the displacement key **43**, with the index **5** being positioned on the final task of the list, the processing of the current list is then completed and the title of the next list appears on the screen framed by the index **55**. If the displacement key **43** is re-activated, the list of tasks corresponding to the next piloting phase then appears on the screen. Sometimes, two lists of tasks correspond to the same piloting phase. In this case, if the context managed by the central processing unit allows a selection to be made between these two lists, the selected list appears on the screen. If the central processing unit is unable to decide on which list is to be executed, a selection menu is submitted to the operator and the list selected via this menu is then displayed.

On the screen represented on FIG. **6**, the key "PREV. PAGE" **14** has been reconfigured in order to be entitled "DEFER ITEM" **57**. If this key is activated, the processing of the task designated by the index **55** is deferred and the index shall frame the wording of the next task (FIG. **7**). At this moment, the operator is asked to confirm the defer of the task designated by the index **55**. To this effect, the keys **33,34** entitled "YES" and "NO" make it possible to validate or non-validate this defer.

If the operator finally decides not to defer the task designated by the index, he activates the key "NO" **34** and the screen reassumes the preceding aspect (FIG. **6**) as if the key **14** reconfigured to "DEFER ITEM" had never been activated.

On the other hand, if the operator activates the key **33** entitled "YES" to confirm his request for task execution deferred, as shown on FIG. **8**, the line containing the wording of the deferred task remains marked, but this time by a full frame **63** (shown by the hatching) and the index **55** is positioned on the next task. The key **12** then takes up the denomination "DEFERRED C-L ITEM" **65** indicating that at least one task has been deferred and the processing of the list may then be continued as previously described.

At a strategic moment during the course of the flight, a mesage may be given to the operator and displayed at the bottom of the screen asking him to execute the deferred tasks. This means that at this moment, so as to continue processing the lists of tasks, the deferred tasks need to be firstly executed and validated. The displacement key of the index **43** is then disactivated. In fact, the safety instructions require that all the actions be accomplished at precise moments and especially prior to undertaking certain flight phases (running, lift-off, landing).

So as to ensure that the displacement key **43** is again activatable, the key **12** entitled "DEFERRED C-L ITEM" needs to be activated which has the effect of making the page containing the first deferred task appear. An action on the displacement key **43** makes it possible to have disappear one after the other and in the order they appear in the lists those markers **63** surrounding the carried tasks for the purpose of validating them.

When all the deferred tasks are validated, the title "DEFERRED C-L ITEM" **64** disappears and the key **12** becomes inoperative. The sequencing of the lists is then restored, thus rendering it possible to display and process the next list.

This defer function introduces more flexibility into the method described above whilst guaranteeing that all the tasks are executed before starting a critical flight phase.

On the other hand, when the operator interrupts the processing of a list so as to activate another main function of the terminal, the state indicator **46** of the key "CHECK LIST" **31** flashes slowly to remind him that the processing of a list is not finished.

Furthermore, when the central processing unit **2** receives an abnormal event corresponding, for example, to a malfunction, of one of the other items of the embarked electronic equipment, an arrow **66** pointing onto the key "CHECK LIST" **31** is displayed on the screen (FIG. **4**). The purpose of this arrow is to induce the operator to press on this key. If in this state the key "CHECK LIST" **31** is activated, the screen shown on FIG. **9** appears. This screen represents the list of the titles of the lists of urgent tasks and an index **68** is prepositioned on the title of the list to be executed so as to correctly react to the malfunction. This disposition makes it possible to inform the operator of the list best adapted to the context, whilst allowing him the choice of selecting another list by means of the displacement key **43**. When the operator presses on the key "ENTER" **17**, the selected list appears on the screen so as to be able to be processed in the same way as the list shown on FIG. **6**. However, at the end of processing of the list, the central processing unit **2** is able to chain other lists of tasks according to the change of this abnormal situation. By means of these dispositions, the lists of urgent tasks are rapidly accessible independent of their frequency of use by taking account of the context of the flight.

What is claimed is:

1. A method for assisting the piloting of an aerodyne and implemented by a system including a processor, at least one man/machine communication terminal comprising a display screen and control and data entry keys and memories where are stored in particular all data useful to operating a flight and that required to conduct a flight in accordance with air regulations, the system being connected to other items of electronic equipment embarked on the aerodyne, wherein said method includes the following stages:

entering and classifying said data in the memories in the form of a data base in which links are established between each of possible contexts of said aerodyne and data most suitably adapted to said context, each of said links being associated with an order of relevance with respect to the linked context, the operator being provided by the terminal with first means for exploiting these data;

acquiring in real time by said processor all data sent by said other items of electronic equipment, said sent data determining a current context of said aerodyne;

preselecting by said processor from the data base the data which are linked to the current context and classifying said preselected data by using said orders of relevance associated with said links;

providing the operator through said terminal with second means for exploiting the preselected classified data;

selecting by the operator one of the exploitation means and one portion of said preselected data; and

exploiting on the display screen by the operator the portion of the preselected data with the aid of the selected exploitation means.

2. The method according to claim **1**, wherein the data base

includes a plurality of lists of tasks, each list indicating for a specific aerodyne context all the tasks to be carried out and their sequencing, said method including:

preselecting a list of tasks which is linked to the current context through a link associated with a highest order of relevance with respect to the current context of the aerodyne,

activating by the operator a first exploitation means for:

displaying the preselected list by the processor on the screen of said terminal,

activating by the processor a first key for positioning a marker which designates the first task to be carried out from the list displayed on the screen, thus provoking the launching of processing of the list, and

processing the list during which said marker is moved from one task to another and during which the operator has to press a second key of said terminal so as to validate the task designated by said marker when the latter is executed, the marker then designating the next task.

3. The method according to claim **2**, wherein the displaying of the preselected list of tasks is triggered by a third key of said terminal, said key in an active state enabling the operator to again display the current list if processing of said current list has been interrupted so as to activate another exploitation means.

4. The method according to claim **3**, further comprising displaying a special indicator close to the third key for inducing the operator to trigger the displaying of this list of tasks when an abnormal event has occurred.

5. The method according to claim **2**, further comprising displaying detailed comments concerning the list of tasks present on the display screen, said display being triggered by a fourth key of said terminal.

6. The method according to claim **2**, further comprising deferring execution of the task designated by said marker, triggered by a fifth key of said terminal, said deferring consisting of moving said marker so as to designate the next task, displaying another marker marking said deferred task, and simultaneously rendering activatable a sixth key so as to allow for validation of all the deferred tasks one after the other and according to the order in which the deferred tasks have been deferred.

7. The method according to claim **6**, wherein the processing of a list of tasks may be blocked by the processor when the current context of the aerodyne requires that all the deferred tasks be executed and when at least one task has been deferred.

8. The method according to claim **2**, wherein when at page is displayed on the screen of said terminal a state indicator is associated with the third key so as to indicate at any moment whether or not a list of tasks is currently being processed, irrespective of said page.

9. The method according to claim **1**, further comprising the following stages:

initializing a context of the flight and consisting of entering, by means of said terminal, airport references for designating a departure airport, a destination airport and possibly an alternate airport;

preselecting by the processor sets of data concerning said airports;

activating by the operator a second exploitation means for:

selecting by the operator one of said airports;

displaying on said display screen by the processor a list of titles of the preselected sets of data concerning the selected airport, thus enabling the operator to select the set he wishes to consult;

selecting by the operator a set to be consulted;

displaying on said display screen page by page by the system the selected set with possibility for the operator of displaying next and preceding pages and again display the list of the titles of the sets so as to allow for displaying another set.

10. The method according to claim **1**, further comprising activating by the operator a third exploitation means for storing as ordered by the operator a page displayed on the screen inside an easily and quickly accessible memory space.

11. The method according to claim **10**, wherein said memory space includes several subdivisions, one first subdivision being allocated to the departure airport, a second to the destination airport and a third to the alternate airport.

12. The method according to claim **11**, wherein said system includes several terminals, said memory space including other subdivisions allocated to any page and respectively associated with the terminals.

13. The method according to claim **12**, wherein the storing of the page displayed on the screen of one terminal of said terminals in one of said first, second and third subdivisions or in the subdivision associated with said one terminal depends on the contents of said page and is triggered by a seventh key of said one terminal.

14. The method according to claim **12**, further comprising storing a page displayed on the screen in the subdivision associated with the terminal when said page does not concern any of said airports, said storage being triggered by a seventh key of the terminal.

15. The method according to claim **12**, further comprising displaying on the screen of one of the terminals the contents of said first, second and third subdivisions and the specific subdivision of the terminal, this display being triggered by an eighth key of said terminal, the displaying of the contents of the subdivisions respectively associated with the other terminals not being authorized.

16. The method according to claim **15**, wherein during said displaying the contents of a subdivision is presented by order of decreasing relevance with respect to the current context.

17. The method according to claim **15**, further comprising, at the same time as displaying on the screen a page stored in a subdivision, allocating said seventh key for suppressing said page from the subdivision where said page is stored until a page is displayed which is not already stored in a subdivision so as to prohibit the storing of the same page more than once.

18. The method according to claim **11**, further comprising storing a page displayed on the screen in a fourth subdivision allocated to any page, said storing being triggered by a ninth key of said terminal.

19. The method according to claim **18**, further comprising displaying on any of the terminals of the contents of the fourth subdivision, said display being triggered by a tenth key of said terminal.

20. A device for assisting the piloting of an aerodyne, comprising:

a processor connected to other items of electronic equipment embarked on the aerodyne for acquiring in real time data relating to a current context of the aerodyne,

at least one man/machine communication terminal connected to the processor and comprising a display screen and control and data entry keys, and

memories accessible by the processor where all data

useful and required to conduct a flight in accordance with air regulations is stored in the form of a data base in which links are established between each of possible contexts of said aerodyne and data most suitably adapted to said context, each of said links being associated with an order of relevance with respect to the linked context,

the processor including:

first means for exploiting the data of the data base,

means for storing and updating said data related to the current context of the aerodyne,

means for preselecting in the data base the data which are linked to said current context and for classifying said preselected data by using said orders of relevance associated with said links,

second means for exploiting the classified preselected data.

21. A man/machine communication terminal for assisting the piloting of an aerodyne, connected to a system comprising:

a processor connected to other items of electronic equipment embarked on the aerodyne for acquiring in real time data relating to a current context of the aerodyne,

memories accessible by the processor where in particular all the information useful for the conducting of a flight and data useful and required to conduct a flight in accordance with air regulations is stored in the form of a data base in which links are established between each of possible contexts of said aerodyne and data most suitably adapted to said context, each of said links being associated with an order of relevance with respect to the linked context,

the processor including:

first means for exploiting the data of the data base,

means for storing and updating said data related to the current context of the aerodyne,

means for preselecting in the data base the data which linked to said current context, and means for classifying said preselected data by using said orders of relevance associated with said links, and

second means for exploiting the classified preselected data,

wherein said terminal comprises a display screen and keys for entering information and carrying out commands, said keys being divided at the periphery of the screen into four sets of successive keys, a first set being allocated to activation of the exploitation means, a second set to carry out selections when a menu is displayed on the screen, a third set being allocated to management functions of the terminal, and a fourth set to display last selections made by the operator and reactivate said last selections, said keys being reconfigurable according to a page displayed on the screen and each being associated with an adjacent zone of the screen where the function allocated to it is displayed.

22. The terminal according to claim 21, wherein each of said keys is associated with a status and a status indicator displayed on the screen, said status having a value equal to active, activatable or non activatable which corresponds to a state of a function triggered by the key.

23. The terminal according to claim 22, wherein the keys allowing for displaying of the final selections are respectively associated with one zone of the screen where wordings of these selections are featured, the key associated with the final selection being non activatable and the others keys associated with the final selections being activatable for displaying the last page displayed concerning the corresponding selection.

24. The terminal according to claim 21, wherein said display screen includes four edges along which said four sets of keys are respectively disposed.

25. The terminal according to claim 21, further comprising a key for displaying a previously selected menu.

* * * * *

US006690298B1

(12) **United States Patent**
Barber et al.

(10) **Patent No.: US 6,690,298 B1**
(45) **Date of Patent: Feb. 10, 2004**

(54) **ENHANCED VERTICAL TERRAIN PROFILE DISPLAY**

(75) Inventors: **Sarah Barber**, Robins, IA (US); **Roger D. Burns**, Cedar Rapids, IA (US)

(73) Assignee: **Rockwell Collins, Inc.**, Cedar Rapids, IA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 58 days.

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(22) Filed: **Jan. 23, 2002**

(51) **Int. Cl.**[7] **G01C 21/00**
(52) **U.S. Cl.** **340/971**; 340/979
(58) **Field of Search** 340/945, 971, 340/979, 980, 961, 963; 342/120, 121

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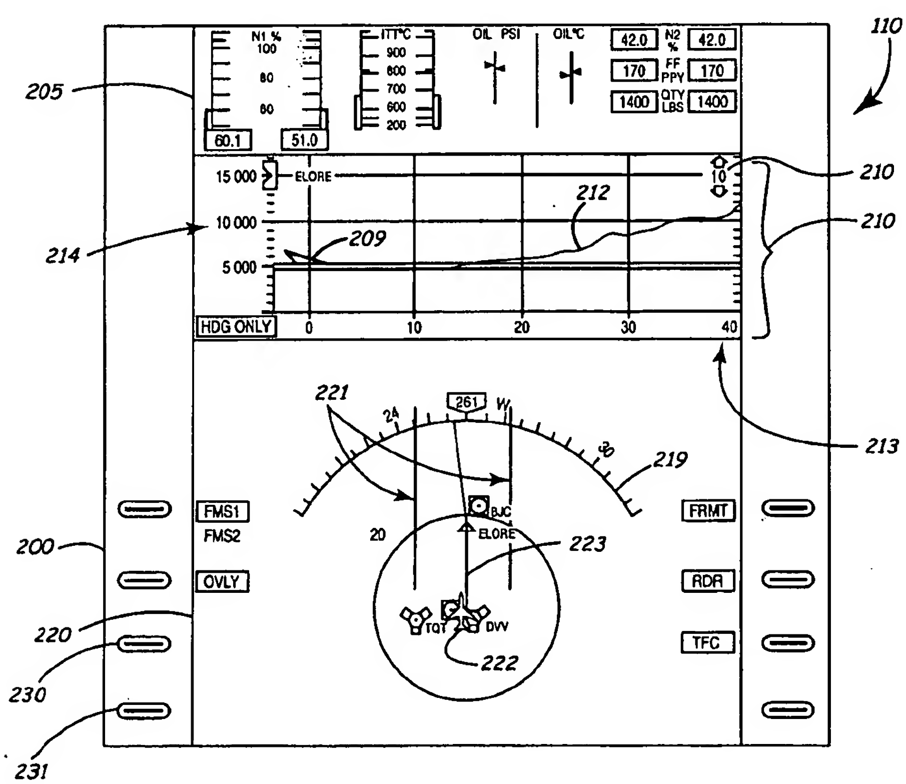
* cited by examiner

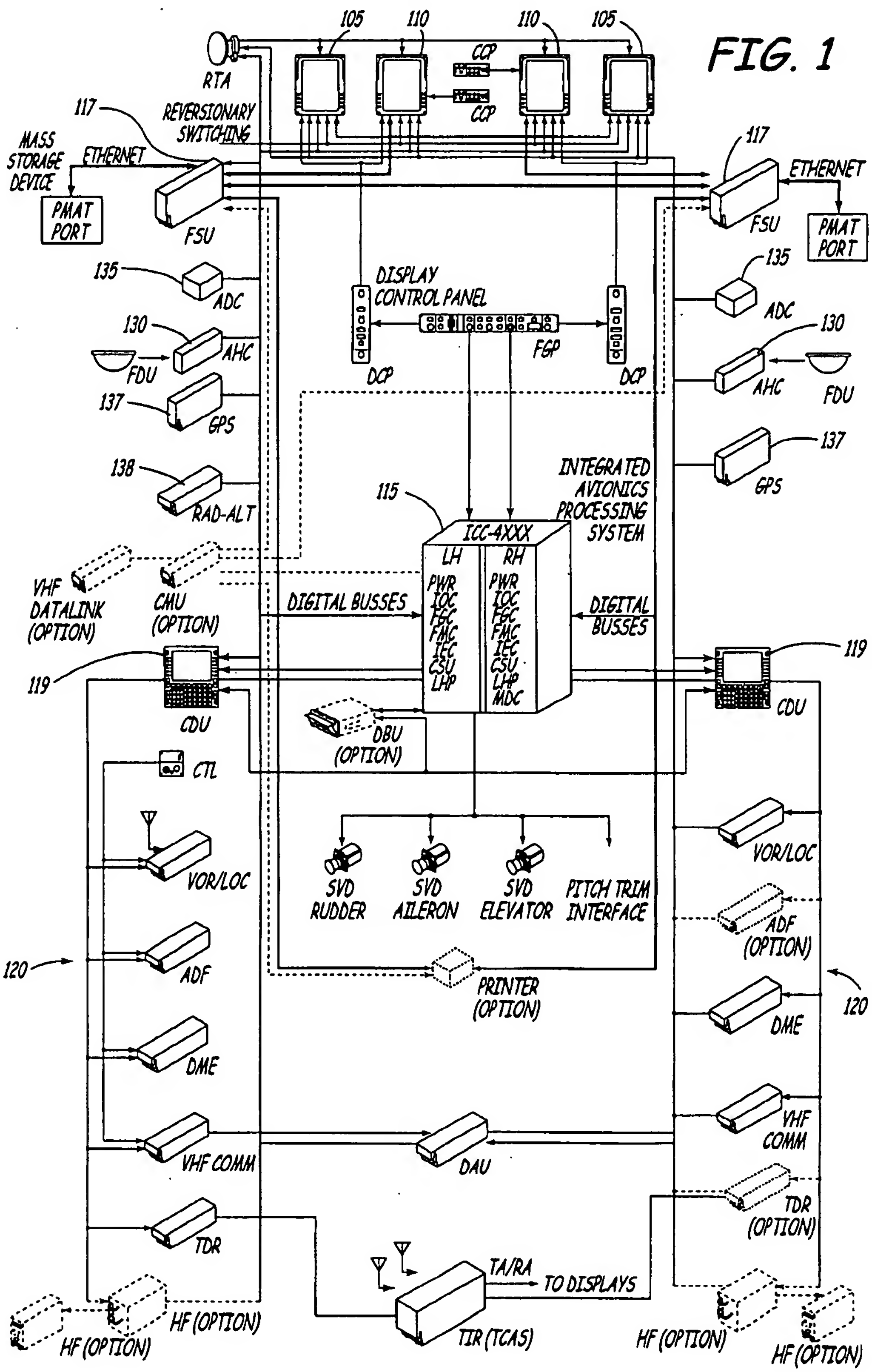
Primary Examiner—Van Trieu
(74) *Attorney, Agent, or Firm*—Nathan O. Jensen; Kyle Eppele

(57) **ABSTRACT**

A flight display for use in an avionics system has a visual display format to show an enhanced vertical situation of an aircraft. Included is a vertical terrain profile display that displays terrain in front of the aircraft over a selected range and a selected swathe width. The vertical terrain profile display shows a side-on terrain profile view with a digital display of the selected swathe width and a display of range in front of the aircraft. A plan view of the aircraft position is included that shows swathe lines on either side of an aircraft to show the selected swathe width. A means for selecting the swathe width by the pilot is provided. The flight display the vertical terrain profile display may be changed into a end-on vertical terrain profile view over the selected swathe width. The end-on terrain profile view has a digital display of the selected range and a digital display of the selected swathe width on each side of the aircraft.

21 Claims, 3 Drawing Sheets

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110
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RTA
CCP
CCP
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REVERSIONARY SWITCHING
MASS STORAGE DEVICE
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PMAT PORT
FSU
117
ETHERNET
FSU
PMAT PORT
135
ADC
135
ADC
DISPLAY CONTROL PANEL
FGP
DCP
DCP
130
AHC
FDU
130
AHC
FDU
137
GPS
137
GPS
138
RAD-ALT
115
INTEGRATED AVIONICS PROCESSING SYSTEM
ICC-4XXX
LH
RH
PWR IOC FGC FMC IEC CSU LHP
PWR IOC FGC FMC IEC CSU LHP MDC
VHF DATALINK (OPTION)
CMU (OPTION)
DIGITAL BUSSES
DIGITAL BUSSES
119
CDU
119
CDU
DBU (OPTION)
CTL
VOR/LOC
VOR/LOC
ADF (OPTION)
SVD RUDDER
SVD AILERON
SVD ELEVATOR
PITCH TRIM INTERFACE
120
ADF
PRINTER (OPTION)
DME
DME
120
VHF COMM
VHF COMM
DAU
TDR
TDR (OPTION)
TA/RA
TO DISPLAYS
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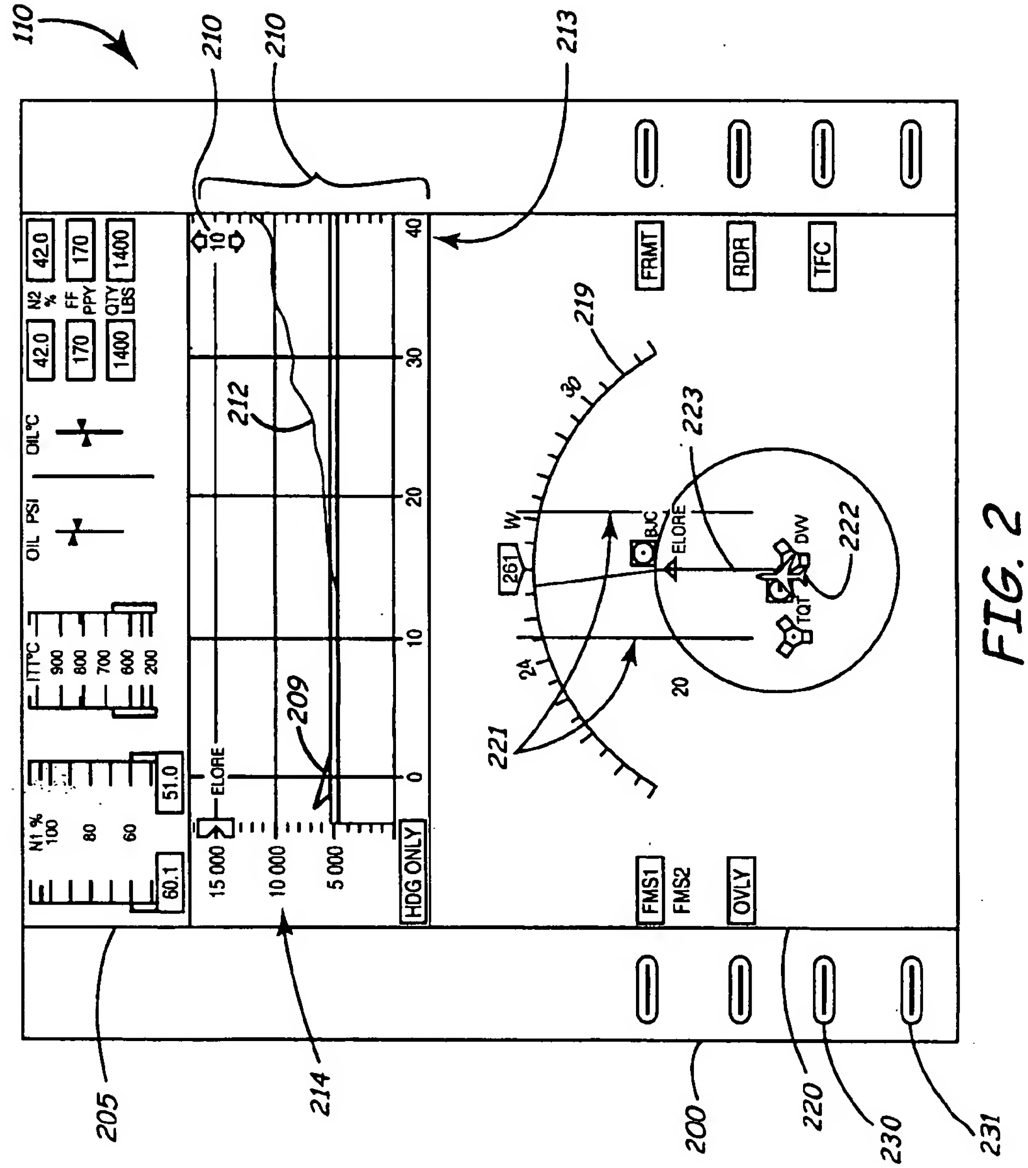
HF (OPTION)
HF (OPTION)
HF (OPTION)
HF (OPTION)

FIG. 1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210
210
213
N1 %
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OIL°C
N2 %
FF PPY
QTY LBS
42.0
170
1400
60.1
51.0
ELORE
HDG ONLY
FRMT
RDR
TFC
FMS1
FMS2
OVLY
261
BJC
ELORE
DVV
TQT
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200
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230
231

FIG. 2

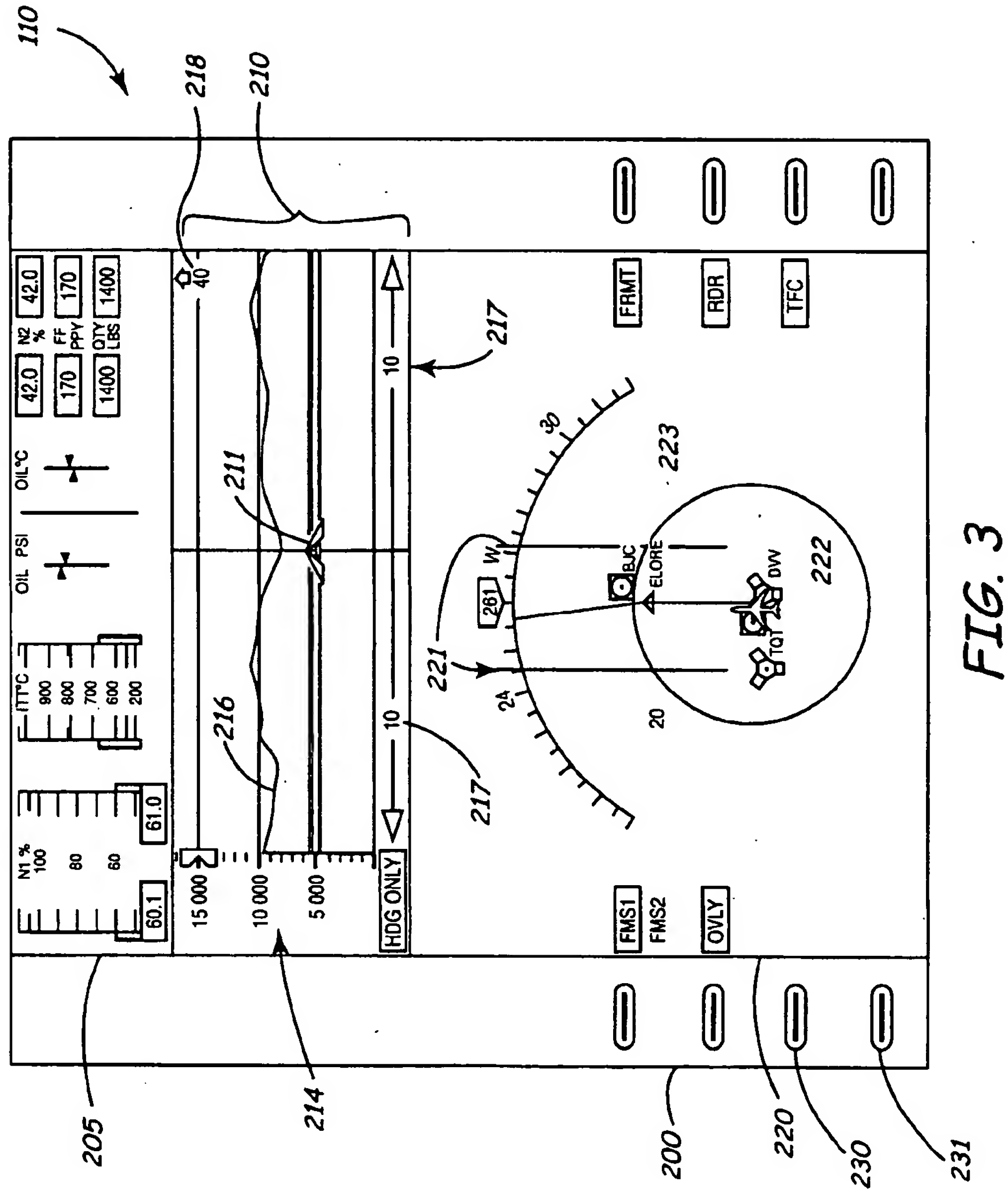

FIG. 3

ENHANCED VERTICAL TERRAIN PROFILE DISPLAY

BACKGROUND OF THE INVENTION

This invention relates to avionics systems, flight displays, and more particularly to enhancements in the display of a vertical terrain profile (VTP) on an avionics flight display for providing a real-time, dynamic display of any terrain hazards so as to prevent controlled flight into terrain (CFIT). Controlled flight into terrain continues to plague air travel as one of the leading causes of fatal aircraft crashes.

Improved methods of alerting a flight crew of potential CFIT conditions have been developed as a result of technology advancements. These technology enhancements include accurate aircraft present position information, terrain data and suitable storage means, and computer processing resources. One such improved alerting system is referred to as a Ground Collision Avoidance System (GCAS). The GCAS system utilizes aircraft present position information, aircraft state information, and a digital terrain database to determine a flight path of an aircraft relative to the surrounding terrain. Such a system is described in U.S. Pat. No. 4,224,669 herein incorporated by reference in its entirety.

Terrain awareness displays that use a format that provides a pilot or flight crew with complete situational awareness of potential terrain hazards to the aircraft are known. Positional information and terrain data in a database are used to display horizontal and vertical terrain information on a flight display. The information is formatted to provide an interface that provides the data conveniently, simply, and intuitively in a format that is easily assimilated and interpreted by a human operator. Such a terrain awareness display is disclosed in U.S. Pat. No. 5,936,552 herein incorporated by reference in its entirety. Shown in this reference is a vertical terrain profile for a terrain path in a line directly in front of the aircraft out to a selected distance.

Vertical terrain profiles may be shown on primary flight displays (PFD) and multifunction displays (MFD) or other display means on an aircraft. What is typically presented to a pilot on a PFD or MFD is a vertical terrain profile in front of an aircraft out to a preselected range. A problem with the vertical terrain profile is that the terrain representation is interpreted through software routines that automatically define a swathe along and either side of the aircraft horizontal flight path or heading/track. This swathe is predefined and the pilot has no control over its width. Moreover, the swathe is completely hidden from the pilot who has no visual cue as to the swathe width currently being used to interpret the terrain data.

What is needed is vertical terrain profile display that displays swathe width information in various formats and allows a pilot to select the swathe width to further enhance the situation awareness of a pilot to prevent CFIT accidents.

SUMMARY OF THE INVENTION

A flight display for use in an avionics system is disclosed. The flight display has a visual display format to show an enhanced vertical situation of an aircraft comprising a vertical terrain profile display of terrain in front of the aircraft over a selected range and a selected swathe width. The vertical terrain profile display shows a side-on terrain profile view that includes a digital display of the selected swathe width and a digital display of range in front of the aircraft in predetermined increments up to the selected range. The flight display includes a plan view of the aircraft position that further comprises swathe lines on either side of an aircraft showing the selected swathe width. The flight display also includes a means for selecting the swathe width.

The flight display also includes means for changing the vertical terrain profile display into a end-on vertical terrain profile view over the selected swathe width. The end-on terrain profile view also includes a digital display of the selected range and a digital display of the selected swathe width on each side of the aircraft on the end-on terrain profile view.

The flight display plan view may be a compass display with the swathe lines projecting forward and parallel to an aircraft heading/track. The plan view may also be a map display with the swathe lines following an aircraft flight path.

The side-on terrain profile view, the end-on terrain profile view, and the swathe lines may be shown in red on the vertical terrain profile display when the terrain is at or above an aircraft altitude.

The means for selecting the swathe width and for changing the vertical terrain profile display may be a knob, joystick, toggle switch, pushbutton or line select key.

It is an object of the present invention to enhance situational awareness of a pilot by providing enhanced vertical terrain profile views on a flight display.

It is an object of the present invention to provide a pilot a means and method to select and display a swathe width of a vertical terrain profile view.

It is an advantage of the present invention to provide a pilot a means and method of selecting a side-on and end-on vertical terrain profile view.

It is an advantage of the present invention to provide a pilot a plan view showing a selected vertical terrain profile swathe width.

It is a feature of the present invention to present terrain information in color with red indicating terrain at an altitude equal to or greater than that of an aircraft.

It is a feature of the present invention to present terrain information in color with yellow indicating terrain at an altitude within a predetermined distance below an aircraft.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be more fully understood by reading the following description of the preferred embodiments of the invention in conjunction with the appended drawings wherein:

FIG. 1 is block diagram of an avionics system incorporating the present invention;

FIG. 2 is a diagram showing a multifunction display having a side-on vertical terrain profile display and a plan view display incorporating the present invention; and

FIG. 3 is a diagram showing the multifunction display of FIG. 2 with an end-on vertical terrain profile display format of the present invention.

DETAILED DESCRIPTION

A typical avionics system **100** that may employ the present invention is shown in exemplary fashion in FIG. **1**. The avionics system **100** shown in FIG. 1 is intended for installations in such aircraft as business aircraft, airliners, and other large aircraft. An avionics system such as that shown in FIG. **1** is manufactured by the assignee of the present invention Rockwell Collins Inc.

The avionics system **100** shown in FIG. 1 may have two electronic flight displays that function as a primary flight

display (PFD) 105 and a multifunction display (MFD) 110. Alternate numbers of displays may be used. A PFD 105 and an MFD 110 are typically mounted in front of both a pilot and a copilot. To allow for the failure of either the PFD 105 or the MFD 110, each is capable of being pilot-configured to a PFD/MFD format. The PFD/MFD format provides all the instrumentation required for the safe operation of the aircraft. A cursor control panel (CCP) 145 is connected to the MFD 110 to access and manipulate features available on the MFD 110. A CCP 145 is available to both the pilot and copilot.

Also include in the avionics system 100 is an integrated avionics processing system (IAPS) 115 that performs part of the integration functions to interconnect and manage the various avionics subsystems in an aircraft. Included in the IAPS 115 are such items as flight control computers, flight management computers, and maintenance diagnostic computers. Dual cockpit control units (CDU) 119 are provided for integrated multisensor navigation, flight maintenance and execution, sensor control, MFD 110 map support, communications equipment control, and other controls to the avionics system 100. Dual file server units (FSU) 117 provide processing and mass storage databases for the avionics system 100. Two FSUs 117 are provide in the typical system of FIG. 1 for redundancy. Each FSU 117 provides full functionality The FSUs are used to store terrain data and other databases used by the avionics system 100. Various data buses including Ethernet buses interconnect and transfer data between the components in the avionics system 100 as shown by the interconnect lines in FIG. 1. Other components in the typical avionics system 100 are air data computers (ADC) 135, engine indication system (not shown), attitude heading computers (AHC) 130, GPS receivers 137, and a radio altimeter 138. Also connected to the avionics system 100 are various radio systems 120 and their associated antennas. These radio sensors may include VOR/LOC, ADF, DME, ILS, and MLS systems to provide navigational information.

A typical MFD 110 front panel 200 including bezel mounted line select keys is shown in FIG. 2. The upper region 205 of the MFD 110 is used to display the EIS (engine indication system) data. NI (turbine fan speed), ITT (inter-turbine temperature), fuel quantity, N2, fuel flow, oil pressure and temperature are displayed in FIG. 2.

A lower region 220 of the MFD front panel 200 is used to display a plan view having compass rose or arc 219 or optional map navigation format as selected by the pilot. A compass arc is shown in FIG. 2 with a horizontal display aircraft symbol 222 indicating the aircraft position and an aircraft heading 223 displayed on the compass arc 219. The space to either side of the rose, arc, or map format is used to display a lateral navigation data field, a weather radar mode field, system messages and selected menu data. Normal control, reversion, and warning annunciations are also displayed.

Shown on the MFD 110 in FIG. 2 is a vertical terrain profile (VTP) display 210 with an aircraft symbol 209 indicating the aircraft altitude. The VTP display 210 presents to the pilot a side-on vertical terrain profile view of the aircraft 209 vertical situation in FIG. 2. The VTP display 210 format is obtained by determining aircraft location from such position determination means on board the aircraft such as the GPS receiver 137 in FIG. 1. The position, altitude, and heading/track of the aircraft are used with the terrain database information in the database of the FSU 117 to form a side-on vertical terrain profile 212 in the FSU 117 processor and pass the data to the MFD 110 for display. The side-on vertical terrain profile 212 is shown out to a selected range (213), b 40miles in this example. This selected range 213 corresponds to the pilot-selected range of the map navigation format that may be displayed in the lower region plan view 220 of the MFD 110. The vertical terrain profile display 210 may also be used to show an aircraft vertical flight path and waypoint locations (not shown). Also shown in the VTP display 210 in the side-on vertical terrain profile view are altitude indications 214 to the, left and increments (10 miles in this example) in the selected range 213 along the bottom of the VTP display 210. The altitude of the aircraft 209 on the VTP display 210 may be determined from the altimeter 138 or the GPS receiver 137 in the avionics system 100 of FIG. 1.

A problem with the VTP display 210 in FIG. 2 in prior art systems is that the terrain representation is interpreted through software that automatically define a swathe along either side of the aircraft's horizontal flight path or heading. The swathe width is predefined and the pilot has no control over its width.

An enhancement to the VTP display 210 of the present invention is to provide the pilot with a manual means of controlling the swathe width and displaying a current setting as a digital display 215 in the VTP display 210. The digital display 215 in the example of FIG. 2 is showing the swathe width as 10 miles on either side of the aircraft 209. A variety of means for selecting a swathe width may be utilized. These include such controls as a knob, pushbutton, toggle select key 230 on the MFD 110 shown in FIG. 2 may also be used to perform the selection function. The side-on vertical terrain profile 212 on the VTP display 210 represents the worst case terrain elevation across the swathe for each increment along the forward path or track.

An additional enhancement to the MFD 110 in FIG. 2 of the present invention is to help increase the situational awareness of the pilot relative to the swathe of terrain that is being interpreted by graphically depicting the swathe width as two swathe lines 221 on the plan view 220 map or compass display. The aircraft 222 having a flight path or heading 223 is located on the plan view 220 compass or flight plan map display. The two lines 221 are located on either side of the aircraft flight path or heading 223 and will move in and out as the swathe width control line select key 230 is activated. Lines 221 will either project directly forward if the VTP 210 is in heading-only mode or follow the shape of a flight path if the VTP 210 is in a flight plan mode (not shown).

An additional enhancement to a VTP display 210 of the present invention is shown in FIG. 3. In FIG. 3 the side-on vertical terrain profile view with side on vertical terrain profile 212 of the VTP display 210 is changed to a look-ahead or end-on vertical terrain profile view with an end-on vertical terrain profile 216. The end-on terrain profile 216 is forward along the flight path and to either side of the flight path to a distance as selected for the current swathe. In FIG. 3, the current selected swathe is shown as 10 miles (217) on either side of an aircraft end-on vertical display symbol 211. The pilot is able to change from the side-on terrain profile 212 of FIG. 2 to the end-on terrain profile 216 of FIG. 3 by using a suitable control such as a knob, pushbutton, joystick, or toggle switch located on the cursor control panel 145. A line select key 231 on the MFD 110 shown in FIG. 2 may also be used to perform the selection function. With the end-on vertical terrain profile view, the pilot may see where a high point in the vertical terrain profile 216 occurs on the right or left of the aircraft 211. With the end-on vertical terrain view, the side-view swathe width indicator 215 of

FIG. 2 now shows a horizontal map range 218 in FIG. 3. The plan view 220 map or compass display of FIG. 2 remains the same in FIG. 3 with the swathe lines 221 located on either side of the aircraft 222 heading as before.

The VTP display 210 may be used to present terrain information in three colors. If the terrain is at or above the aircraft 209 altitude in the side-on view or aircraft 211 altitude in the end-on view, the side-on vertical terrain profile 212 or the end-on vertical terrain profile 216 will be depicted in red. If the terrain is within a predetermined distance such as 1000 feet below the aircraft 209 or 211, the side-on or end-on vertical terrain profile 212 or 216 will be depicted in yellow. If the terrain is lower than 1000 feet below the aircraft, the terrain profiles 212 or 216 will be depicted in brown. The swathe lines 221 on the compass or flight plan display 220 will be displayed in the worst case color currently indicated on the VTP display 210. For example, if any red terrain is visible on the VTP display 210, the swathe lines 221 will be in red. Other colors may be used to make these display indications.

The present invention is described above as being implemented on a multifunction display in an avionics system. As described above the multifunction display and a primary flight display may be utilized interchangeably and the present invention may also be used interchangeably on these flight displays. In addition, other types of flight displays for displaying vertical terrain profiles may be used to incorporate the present invention.

It is believed that the enhanced vertical terrain profile display of the present invention and many of its attendant advantages will be understood by the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the components thereof without departing from the scope and spirit of the invention or without sacrificing all of its material advantages, the form herein before described being merely an explanatory embodiment thereof. It is the intention of the following claims to encompass and include such changes.

What is claimed is:

1. An avionics system having a flight display with a display format to show an enhanced vertical situation of an aircraft said flight display comprising:

- a vertical terrain profile display of terrain in front of the aircraft over a selected range and a selected swathe width said vertical terrain profile display having a side-on vertical terrain profile view further comprising:
  - a side-on vertical terrain profile;
  - a side-on vertical aircraft symbol showing an altitude and position of the aircraft;
  - a digital display of the selected swathe width;
  - a display of range in front of the aircraft in predetermined increments up to the selected range on the side-on profile view; and
- a plan view display of the aircraft position said plan view further comprising:
  - a horizontal display aircraft symbol;
  - swathe lines on either side of a the horizontal aircraft symbol showing the selected swathe width; and
- a manual means for selecting the swathe width.

2. The flight display of claim 1 further comprising means for changing the vertical terrain profile display side-on view Into a end-on vertical terrain profile view over the selected swathe width said end-on terrain profile view further comprising:

- an end-on vertical terrain profile;
- an end-on vertical display aircraft symbol;
- a digital display of the selected range on the end-on terrain profile view; and
- a display of the selected swathe width on each side of the aircraft on the end-on terrain profile view.

3. The flight display of claim 2 wherein the side-on terrain profile, the end-on terrain profile, and the swathe lines are shown in red on the vertical terrain profile display when the terrain is at or above the aircraft altitude.

4. The flight display of claim 2 wherein the side-on terrain profile, the end-on terrain profile, and the swathe lines are shown in yellow on the vertical terrain profile display when the terrain is with a predetermined distance below the aircraft altitude.

5. The flight display of claim 2 wherein the manual means for changing the vertical terrain profile display comprises one of the group comprising a knob, joystick, toggle switch, pushbutton, and line select key.

6. The flight display of claim 1 wherein the plan view comprises a compass display with the swathe lines projecting forward and parallel to an aircraft heading/track.

7. The flight display of claim 1 wherein the plan view comprises a map display with the swathe lines following an aircraft flight path.

8. The flight display of claim 1 wherein the manual means for selecting the swathe width comprises one of the group comprising a knob, joystick, toggle switch, pushbutton, and line select key.

9. A method of displaying enhanced vertical situation information of an aircraft on a flight comprising the steps of:

- displaying a side-on terrain profile view with a side-on vertical aircraft symbol and a side-on vertical terrain profile on a vertical terrain profile display of terrain in front of the aircraft over a selected range;
- selecting a swathe width for the side-on terrain profile view with a manual swathe width selecting means;
- displaying the selected swathe width on the side-on terrain profile view on a digital display;
- displaying a display of range in front of the aircraft in predetermined increments up to the selected range on the side-on profile view;
- displaying a plan view of the aircraft position having a horizontal aircraft symbol;
- displaying swathe lines on either side of the horizontal aircraft symbol on the plan view; and
- showing the selected swathe width by the spacing of the swathe lines on the plan view.

10. The flight display method of claim 9 further comprising the steps of:

- changing the vertical terrain profile display into a end-on vertical terrain profile view having an end-on vertical aircraft symbol and an end-on vertical terrain profile over the selected swathe width;
- displaying the selected range in a digital display on the end-on terrain profile view; and
- displaying the selected swathe width on each side of the aircraft on the end-on terrain profile view.

11. The flight display method of claim 10 further comprising the steps of displaying the side-on terrain profile, the end-on terrain profile, and the swathe lines in red when the terrain is at or above an aircraft altitude.

12. The flight display method of claim 10 further comprising the steps of displaying the side-on terrain profile, the end-on terrain profile, and the swathe lines in yellow when the terrain is within an predetermined distance of the aircraft.

13. The flight display method of claim 10 wherein the step of changing the vertical terrain profile display comprises utilizing one of the group comprising a knob, joystick, toggle switch, pushbutton, and line select key.

14. The flight display method of claim 9 wherein the step of displaying swathe lines on either side of the horizontal aircraft symbol further comprising the step of displaying the swathe lines projected directly forward and parallel to an aircraft heading when the plan view is displaying a compass.

15. The flight display method of claim 9 wherein the step of displaying swathe lines on either side of the horizontal aircraft symbol further comprising the step of displaying the swathe lines following an aircraft flight path when the plan view is displaying a map.

16. The flight display method of claim 9 wherein the step of selecting the swathe width comprises utilizing one of the group comprising a knob, joystick, toggle switch, pushbutton, and line select key.

17. A flight display for use in an avionics system and having a display format to show an enhanced vertical situation display of an aircraft said flight display comprising:

a vertical terrain profile display of terrain in front of the aircraft over a selected range and a selected swathe width said vertical terrain profile display displaying the selected swathe width;

a plan view display of the aircraft position said plan view further comprising swathe lines on either side of an aircraft symbol showing the selected swathe width; and

means for manually selecting the swathe width.

18. The flight display of claim 17 wherein the vertical terrain profile display further comprises a side-on vertical terrain profile view comprising:

a side-on vertical terrain profile;

a side-on vertical aircraft symbol showing an altitude and position of the aircraft;

a digital display of the selected swathe width; and

a display of range in front of the aircraft in predetermined increments up to the selected range on the side-on profile view.

19. The flight display of claim 17 wherein the vertical terrain profile display further comprises an end-on vertical terrain profile view comprising:

an end-on vertical terrain profile;

an end-on vertical display aircraft symbol;

a digital display of the selected range on the end-on terrain profile view; and

a display of the selected swathe width on each side of the aircraft on the end-on terrain profile view.

20. The flight display of claim 17 wherein the plan view display further comprises a compass display with the swathe lines projecting forward and parallel to an aircraft heading.

21. The flight display of claim 20 wherein the plan view display further comprises a map display with the swathe lines following a aircraft flight path.

* * * * *

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(54) **INTERFACE FOR VISUAL CUEING AND CONTROL FOR TACTICAL FLIGHTPATH MANAGEMENT**

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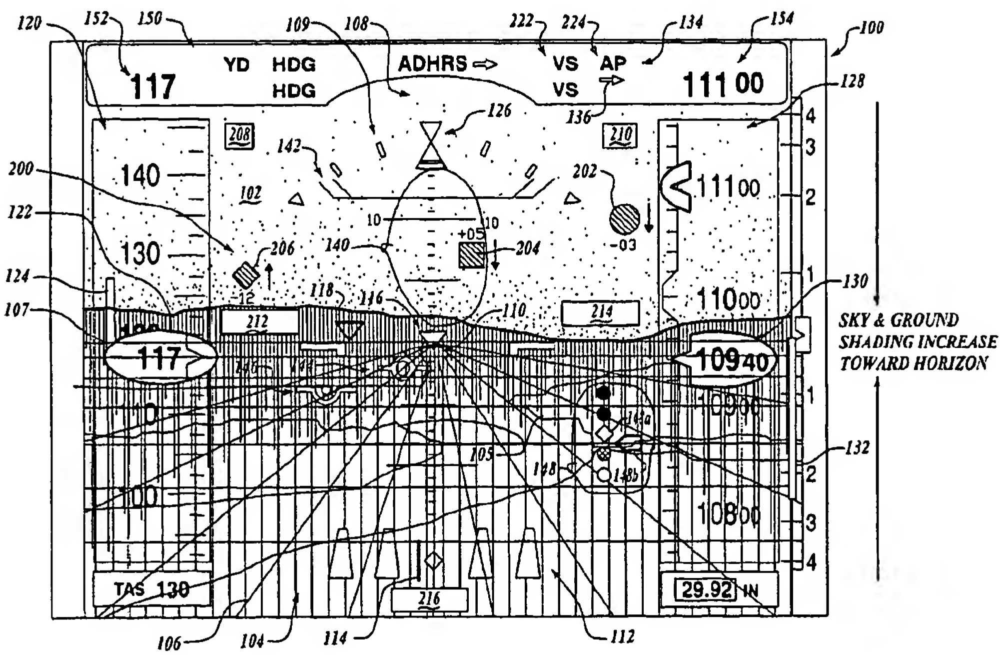
(52) U.S. Cl. 340/973; 340/963

(57) **ABSTRACT**

An apparatus, method and computer program product for an integrated display presentation for tactical flight path management that simplifies instrument flight by replicating many of the cues basic to visual flight using spatial flow, integrating navigation information conformal symbology, and improving instrumentation using an enhanced "T" instrument display.



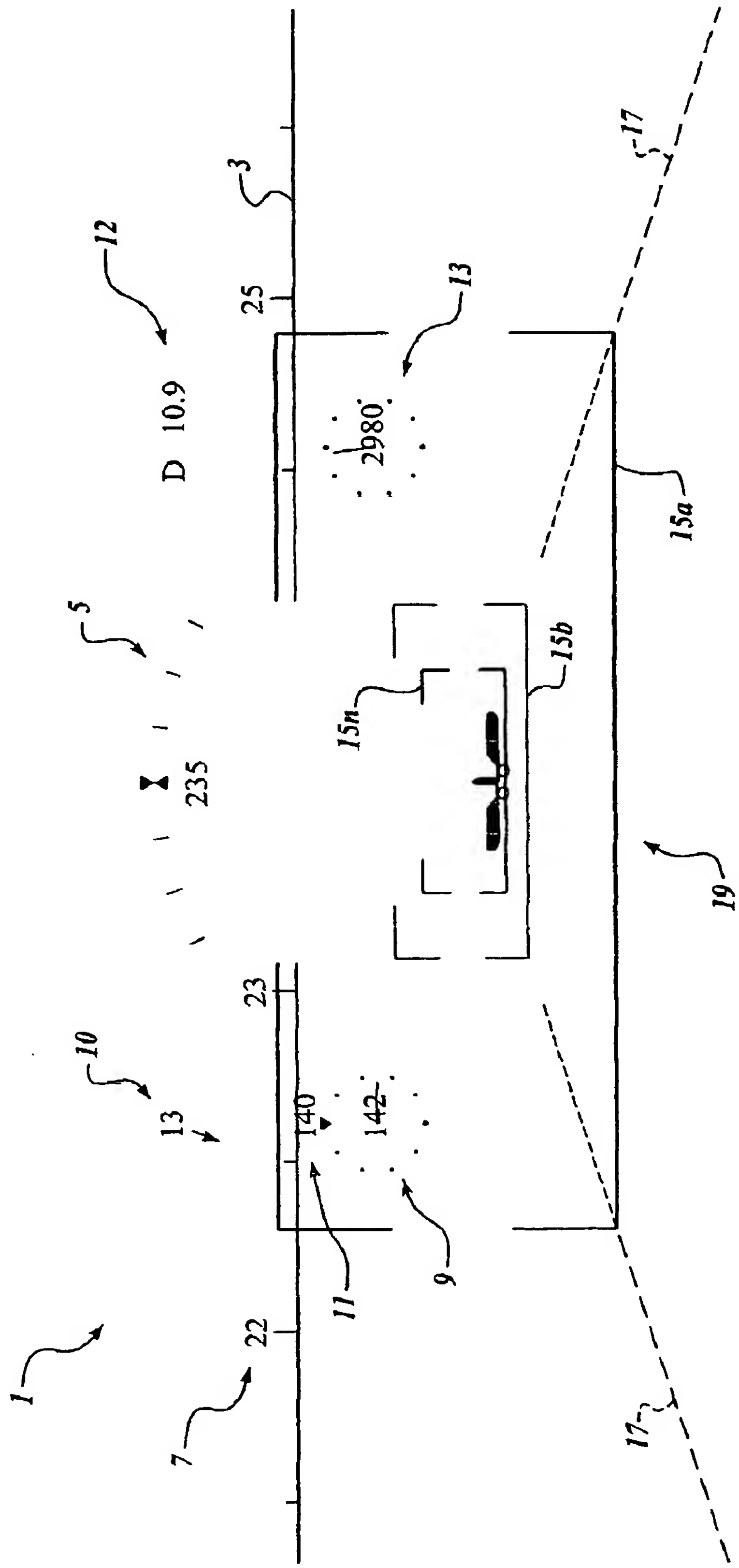


Fig. 1. (PRIOR ART)

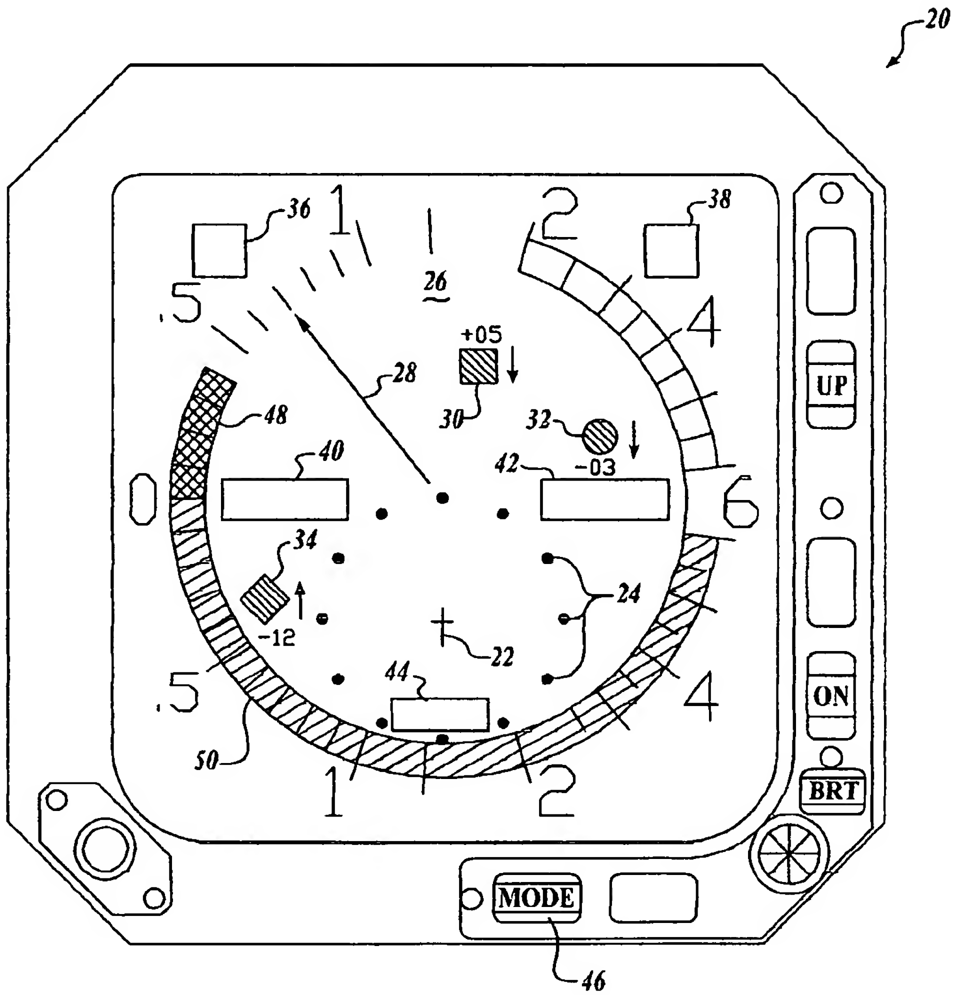


Fig. 2. (PRIOR ART)

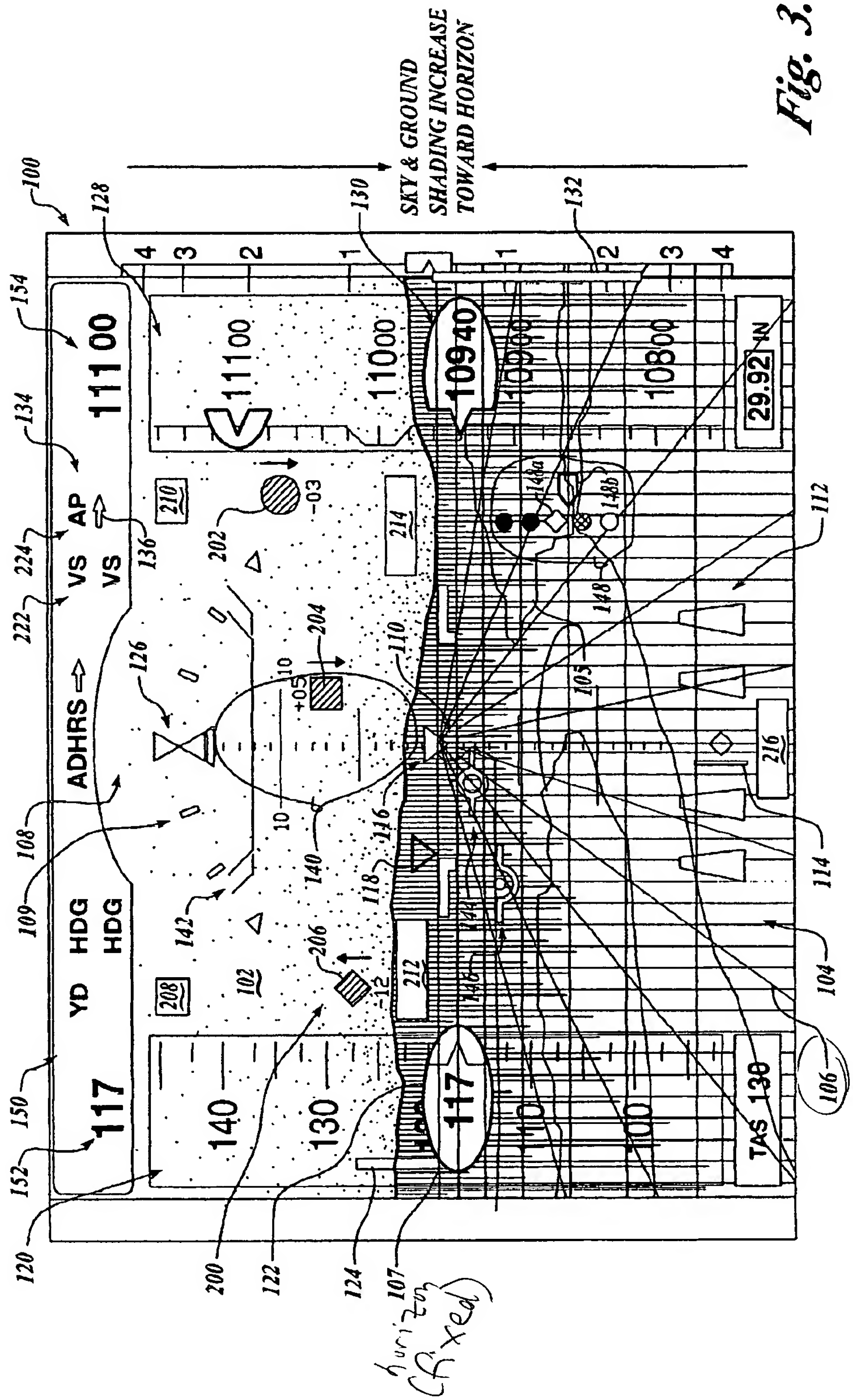

SKY & GROUND
SHADING INCREASE
TOWARD HORIZON
117
YD HDG
HDG
ADHRS
VS
VS
AP
11100
140
130
110
100
TAS 130
11100
11000
10940
10900
10800
29.92 IN
117
horizon (fixed)

Fig. 3.

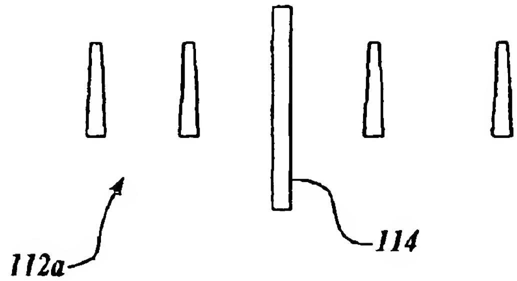


Fig. 4A.

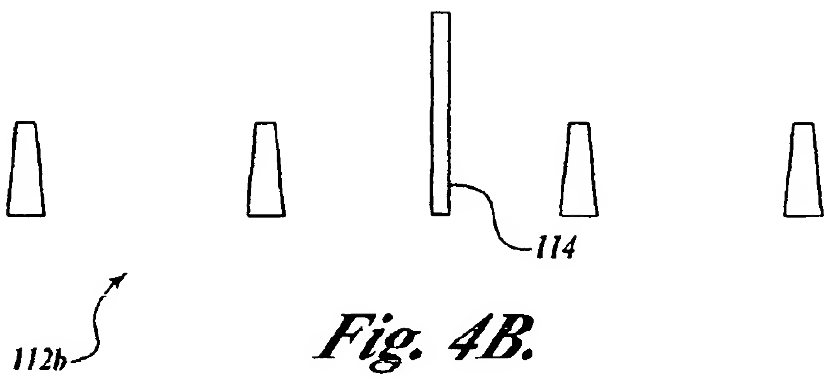


Fig. 4B.

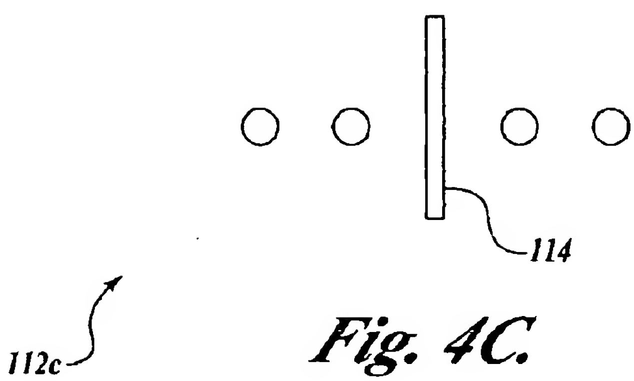
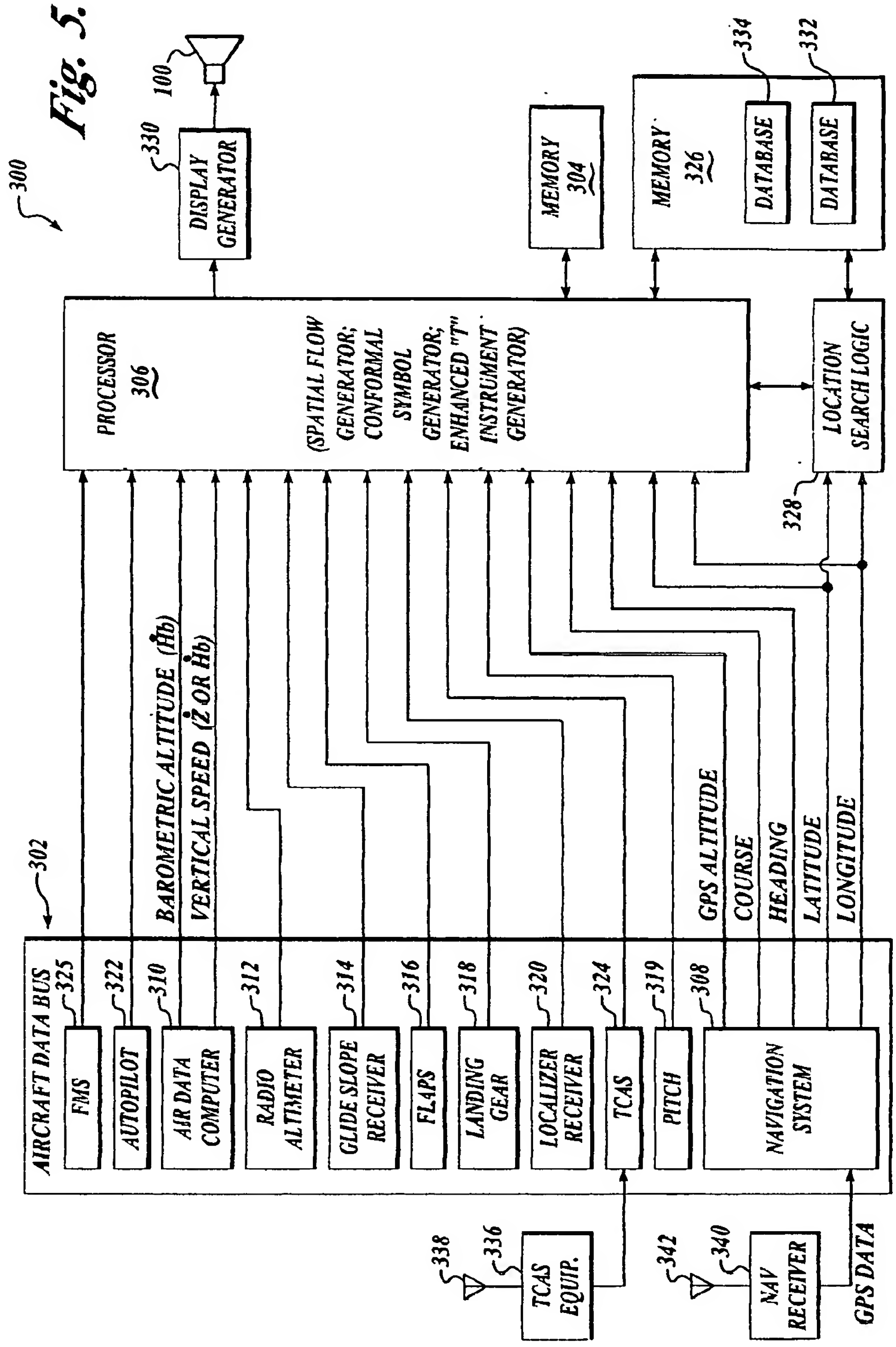


Fig. 4C.


300
DISPLAY GENERATOR
330
100
MEMORY 304
MEMORY 326
DATABASE
334
DATABASE
332
PROCESSOR 306
(SPATIAL FLOW GENERATOR; CONFORMAL SYMBOL GENERATOR; ENHANCED "T" INSTRUMENT GENERATOR)
LOCATION SEARCH LOGIC
328
302
AIRCRAFT DATA BUS
FMS
325
AUTOPILOT
322
AIR DATA COMPUTER
310
RADIO ALTIMETER
312
GLIDE SLOPE RECEIVER
314
FLAPS
316
LANDING GEAR
318
LOCALIZER RECEIVER
320
TCAS
324
PITCH
319
NAVIGATION SYSTEM
308
BAROMETRIC ALTITUDE (Hb)
VERTICAL SPEED (Ż OR Ḣb)
GPS ALTITUDE
COURSE
HEADING
LATITUDE
LONGITUDE
TCAS EQUIP.
336
338
NAV RECEIVER
340
342
GPS DATA
Fig. 5.

INTERFACE FOR VISUAL CUEING AND CONTROL FOR TACTICAL FLIGHTPATH MANAGEMENT

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 60/324,241, filed in the names of Thea L. Feyereisen, Chad L. Cundiff and Ou Zhao on Sep. 21, 2001, the complete disclosure of which is incorporated herein by reference.

[0002] Related patent applications include co-pending U.S. patent application Ser. No. 10/052,716, entitled SIMULATED VISUAL GLIDESLOPE INDICATOR ON AIRCRAFT DISPLAY, filed in the name of Charles L. Hett on Jan. 17, 2002 and co-pending U.S. patent application Ser. No. ______ (Attorney Docket Number H0001712), entitled PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT, filed in the name of Thea L. Feyereisen on Aug. 30, 2002, all assigned to the assignee of the present application and incorporated in their entirety herein by reference.

FIELD OF THE INVENTION

[0003] The present invention relates to cockpit display devices and methods, and in particular to integrated display presentation devices for tactical flight path management that use spatial flow, conformal navigation information, and dynamic instrument presentation.

BACKGROUND OF THE INVENTION

[0004] The "human factor" has been and remains the dominant cause of accidents in General Aviation (GA). Current accident statistics indicate the primary causes of fatal accidents across all GA classes are: maneuvering flight, take-off/initial climb, weather, and approach.

[0005] **FIG. 1** illustrates one embodiment of NASA-sponsored "Highway in the Sky" (HITS) display format embodied in a cockpit display **1**. HITS is an affordable glass cockpit technology that is being developed to improve the safety and ease of GA flying. See, AGATE Flyer (2000). Conventional glass cockpit technology is operated by onboard automation to provide a semblance of perspective by displaying a horizon line **3** on a narrow horizontal and vertical field of view (FOV). A partial compass rose **5** is centered on the display and spread along the horizon line **3** as compass angle ticks **7**. Currently, the standard electromechanical "T" configuration in conventional head-down cockpit displays provides flight data parameters such as air speed (AS) **9**, wind direction and velocity **10**, true air speed (TAS) **11**, DME to next waypoint **12**, and altitude **13** displayed using conventional electromechanical instruments having analog needle pointers or digital readouts. The standard electromechanical "T" configuration may also include other instruments, such as a turn coordinator, a heading indicator, and a vertical speed indicator.

[0006] The HITS technology is operated by the onboard automation to provide a series of rectangular boxes **15*a***, **15*b*** through **15*n***, also known as "paving stones,""goal posts," and by other sobriquets. These boxes **15*a*-15*n*** are depicted along a three-dimensional (3-D) flight plan **17** and form a visual "tunnel"**19** for the pilot to fly through. The HITS technology requires that a 3-D flight plan is stored in the onboard automation to generate the tunnel **19**. Unfortunately, a majority of both GA navigation systems and pilots flying today do not store this information. Nor is the Federal Aviation Administration/Air Traffic Control (FAA/ATC) ready at this time to support uplinked 3-D flight plans. Rather, the 3-D flight plan must be stored manually. Storing the 3-D flight manually is additional pilot workload during the initial flight plan load, and during required en route flight plan updates as well.

[0007] The HITS technology suffers additional human factor issues as well, including poor off-path guidance, display clutter, cognitive tunneling, and pilot complacency. Pilots have reported that HITS may provide inadequate guidance when a pilot is flying off-path or outside the tunnel. When a pilot is off-path, the 3-D HITS tunnel may be out of view and distorted so that the pilot experiences difficulty in gauging a quality and degree of correction required to obtain or regain the flight path.

[0008] An increase in display clutter is another reported concern about the HITS tunnel symbology. Clutter on the HITS display is "masking clutter" whereby the tunnel occludes other display components, and it is also "perceptual clutter" in that the pilot experiences increased difficulty in detecting and interpreting the symbology of adjacent display components.

[0009] Two of the most safety critical issues facing the HITS technology and pilot performance are cognitive tunneling and complacency. Cognitive tunneling or "fixation" is a documented concern of the HITS technology. It has been reported that the "tunnel" symbology can become so compelling that it literally tunnels the pilots attention, whereby the pilot experiences increased difficulty in detecting unexpected events in both the near domain, e.g., airspeed, and the far domain, e.g., other aircraft that may be not be equipped with a transponder. However, even when a pilot does detect an unexpected event, such as identifying a potential intruder aircraft threat, the pilot does not always perform an appropriate response. Rather, the goal-post HITS symbology can promulgate display "loyalty" in that the vertical extensions of a goal post pathway are perceived as barriers that are not to be violated with a lateral avoidance maneuver, even in the face of oncoming traffic.

[0010] Currently, traffic collision avoidance information is provided to the pilot by a well-known Traffic Alert Collision Avoidance System (TCAS) on a navigation display separate from the head-down HITS display. **FIG. 2** illustrates a conventional top-down display **20** used with a Traffic Alert Collision Avoidance System (TCAS) navigation display. In U.S. Pat. No. 6,433,729, entitled SYSTEM AND METHOD FOR DISPLAYING VERTICAL PROFILE OF INTRUDING TRAFFIC IN TWO DIMENSIONS, issued on Aug. 13, 2002, the complete disclosure of which is incorporated herein by reference, Thomas Staggs describes a conventional display **20** of the prior art used with a TCAS collision avoidance system. The conventional display **20** is a top-down display having an aircraft symbol **22** to depict the position of the protected host aircraft. A circle, formed by multiple dots **24** surrounding host aircraft position symbol **22**, indicates an effective range from the host aircraft. Generally, semi circular indicia **26** around the periphery of indicator display **20** and a rotatable pointer **28** together provide an indication of the vertical altitude rate of change of the host aircraft. Indicia **26** are typically marked in hundreds of feet per minute.

[0011] Other target aircraft or "intruders" are identified on display **20** by indicia or "tags"**30, 32** and **34**. Tags **30, 32, 34** are shaped as squares, circles or diamonds and are color coded (not shown) to provide additional information. Square **30** colored red represents an intruder entering warning zone and suggests an immediate threat to the host aircraft with prompt action being required to avoid the intruder. Circle **32** colored amber represents an intruder entering caution zone and suggests a moderate threat to the host aircraft recommending preparation for intruder avoidance. Diamond **34** represents near or "proximate traffic" when colored solid blue or white and represents more remote traffic or "other traffic" when represented as an open blue or white diamond. Air traffic represented by either solid or open diamond **34** is "on file" and being tracked by the TCAS.

[0012] Each indicia or tag **30, 32, 34** is accompanied by a two digit number preceded by a plus or minus sign. In the illustration of **FIG. 2** for example, a "+05" is adjacent square tag **30**, a "–03" is adjacent circle tag **32** and a "–12" is adjacent diamond tag **34**. Each tag may also have an vertical arrow pointing either up or down relative to the display. The two digit number represents the relative altitude difference between the host aircraft and the intruder aircraft; the plus and minus signs indicating whether the intruder is above or below the host aircraft. Additionally, the two digit number appears positioned above or below the associated tag to provide a visual cue as to the intruder aircraft's relative position: the number positioned above the tag indicates that the intruder is above the host aircraft and the number positioned below the tag indicates that the intruder is below the host aircraft. The associated vertical arrow indicates the intruder aircraft's altitude is changing at a rate in excess of 500 feet per minute in the direction the arrow is pointing. The absence of an arrow indicates that the intruder is not changing altitude at a rate greater than 500 feet per minute.

[0013] Display **20** includes several areas represented by rectangular boxes **36, 38, 40, 42, 44** which are areas reserved for word text displays wherein conditions of the TCAS are reported to the pilot of the host aircraft. For example, if a portion or component of the TCAS fails, a concise textual report describing the failure appears in one of rectangular boxes **36, 38, 40, 42, 44**. In another example, if the operator operates mode control **46** to select one of a limited number of operational modes, a concise textual message indicating the choice of operational mode appears in another of rectangular boxes **36, 38, 40, 42, 44**. Selectable operational modes typically include a "standby" mode in which both of the host aircraft transponder systems are inactive, a "transponder on" mode in which a selected one of primary transponder and secondary transponder is active, a "traffic alert" mode in which an alert is transmitted to the protected host aircraft pilot if any Mode-C or Mode-S transponder equipped aircraft are entering a first predetermined cautionary envelope of airspace, and a "traffic alert/resolution advisory" mode in which a traffic alert (TA) and/or resolution advisory (RA) is issued if any Mode-C or Mode-S transponder equipped aircraft are entering a second predetermined warning envelope of airspace. The various operational modes described above are selectable by operating mode control **46**.

[0014] The Vertical Speed Indicator (VSI) portion of indicator display **20**, formed by the semi circular indicia **26** around the periphery and rotatable pointer **28**, are used in the TCAS to indicate a rate of climb or descent that will maintain the safety of the host aircraft. In the particular example of **FIG. 2**, a colored arc portion **48**, referenced by double cross-hatching, of the VSI scale indicates a recommended rate of climb intended to ensure the safety of the host aircraft. Another colored arc portion **50**, referenced by single cross-hatching, of the VSI scale indicates a rate of descent which the TCAS recommends against for the host aircraft in the current situation. The operator of the intruder aircraft receives instructions coordinated with the host aircraft TCAS.

[0015] While TCAS represents one known system for predicting airborne collisions, other predictive systems are also known. For example, U.S. Pat. No. 5,325,302, entitled GPS-BASED ANTI-COLLISION WARNING SYSTEM, issued to Izidon, et al. on Jun. 28, 1994, the complete disclosure of which is incorporated herein by reference, describes a method for predicting a collision between two or more relatively moving aircraft, including determining a respective position in space for each one of the aircraft relative to a fixed frame of reference at a predetermined frequency to produce successive frames of positional data for each aircraft with a coupled memory for storing the successive positional data frames, computing a trajectory for each aircraft relative to the fixed frame of reference, and predicting whether two or more trajectories will intersect.

[0016] In U.S. Pat. No. 6,433,729, Staggs teaches a displaying showing a vertical profile view of situational awareness information. Staggs teaches reducing 3-dimensional traffic data into a 2-dimensional vertical profile view and displaying the situational awareness information in a 2-dimensional display. Conventional horizontal display symbology and processes are utilized, thereby maximizing commonality and avoiding costly retraining of flight crews to interpret data in a new fashion. Furthermore, the method and circuit taught by Staggs are applicable to TCAS or ACAS (Airborne Collision Avoidance System) and to all aerial traffic detection and collision avoidance systems.

[0017] The conventional top-down and 2-dimensional vertical profile views provided for TCAS and ACAS displays are provided on an independent cockpit display such as the display **30** illustrated in **FIG. 2**. During Instrument Flight Rules (IFR) flying, the separate display requires the pilot to divide attention between the two displays. As discussed above, the pilot may succumb to cognitive tunneling while using the HITS cockpit display, and may also succumb to complacency as surrounding traffic is invisible on the HITS head-down display illustrated in **FIG. 1**.

SUMMARY OF THE INVENTION

[0018] Based on currently proposed concepts, HITS suffers from some unresolved documented human factors issues that include storing a 3-D flight plan, clutter, cognitive tunneling and complacency. Therefore, a system is still needed to improve the quality of information flow to the GA pilot. For example, the pilot's ability to perceive spatial relationships is critical to the safety of flight. Spatial flow is a graphical presentation technique that replicates the spatial motion and energy cues available in visual flying. During visual flight, pilots perceive movement and distance by combining evidence about texture, perspective, and color changes. Also, during visual flight, pilots often use land-

marks, e.g., a mountain peak, on the horizon as a guide to a destination. These visual landmarks provide situation awareness. Furthermore, a traditional "T" instrument information configuration provides the pilot with instrument data that can be applied to improve situational awareness.

[0019] However, when flying in Instrument Meteorological Conditions (IMC), the spatial motion and energy cues and the landmarks are not available. Furthermore, the traditional "T" instrument information configuration provides only data, without information and context. The present invention overcomes these limitations of the prior art by providing an integrated head-down or head-up Primary Flight Display (PFD) presentation for tactical flight path management that changes flying Instrument Flight Rules (IFR) to be more like flying Visual Flight Rules (VFR). The integrated Primary Flight Display presentation of the present invention therefore replicates many of the spatial motion and energy cues basic to visual flight using spatial flow, integrates navigation information using substantially conformal symbology, and improves instrumentation using an enhanced "T" instrument display that goes beyond the traditional "T" instrument information configuration to provide the pilot with information and context along with the data.

[0020] The present invention overcomes the limitations of the prior art by providing a display control device having a processor that is coupled for receiving, at a known sampling rate, one or more different instrument data signals each of which reports information about a different flight parameter; and one or more algorithms resident on the processor and executable by the processor. The algorithms are structured to generate a plurality of display control signals as a function of the flight parameter information, the display control signals being structured to cause a display device to display one or more of: graphical depictions symbolic of one or more of a plurality of spatial motion and energy cues of a type available in conventional visual flying, navigation information as graphical depictions symbolic of one or more of a plurality of aerial and ground-based phenomena substantially conformally as a function of the navigation information, and a plurality of graphical depictions symbolic of the different instrument data, one or more of the plurality of graphical depictions being dynamically emphasized as a function of one of the different flight parameters.

[0021] According to one aspect of the invention, the algorithms resident on and executable by the processor are structured to generate display control signals that cause a display device to display the graphical depictions of at least one of the spatial motion and energy cues, at least one of the ground-based phenomena, and at least one of the different instrument data.

[0022] According to another aspect of the invention, the algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues include one or more algorithms that are structured to generate display control signals that cause a display device to display a field of view (FOV) encompassing in the range of about 20-60 degrees in the horizontal and at least the conventional 2-3 degrees in the vertical and as much as 20-30 degrees, the FOV having a sky portion and a ground portion separated by a horizon representation and being superimposed with one or more of texture, perspective, and color features.

[0023] According to another aspect of the invention, the algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues also include one or more algorithms that are structured to generate display control signals that cause a display device to display graduated color features superimposed on one or both of the sky portion and the ground portion of the FOV.

[0024] According to another aspect of the invention, the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues include one or more algorithms that are structured to generate display control signals that cause a display device to display perspective lines superimposed on the ground portion of the FOV.

[0025] According to another aspect of the invention, the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues include one or more algorithms that are structured to generate display control signals that cause a display device to display one or more texture cues on the ground portion of the FOV.

[0026] According to another aspect of the invention, the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the substantially conformal ground-based phenomena further include one or more algorithms that are structured to generate display control signals that cause a display device to display one or more of a substantially conformal runway/airport symbol, a substantially conformal lateral deviation indicator symbol in combination with a substantially conformal lateral path indication symbol, a substantially conformal lateral current waypoint symbol, a substantially conformal next waypoint symbol, and substantially conformal intruder aircraft and collision avoidance symbology. The substantially conformal intruder aircraft and collision avoidance symbology includes intruder aircraft and collision avoidance information supplied by an onboard TCAS (Traffic Alert Collision Avoidance System) or ACAS (Airborne Collision Avoidance System) or another aerial traffic detection and collision avoidance system.

[0027] According to another aspect of the invention, the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the instrument data also include one or more algorithms that are structured to generate display control signals that cause a display device to display one or more of an indicated air speed, an attitude, an altitude, a heading, a pictographic mode of flight indicator, and a simulated visual glideslope. Additionally, one or more algorithms are included that are structured to generate display control signals that cause a display device to display one of the graphical depictions of the instrument data as a dynamically emphasized graphical depiction as a function of one of a mode and a phase of flight. One or more algorithms are included that are structured to generate display control signals that cause a display device to display the dynamically emphasized graphical depiction of instrument data as having a visual appearance different from a nominal visual appearance.

[0028] According to other aspects of the invention, computer program products are provided for receiving the one or more different instrument data signals and generating the plurality of display control signals, as described herein.

[0029] According to yet other aspect of the invention, the invention provides methods for receiving the one or more different instrument data signals and generating the plurality of display control signals, as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0031] **FIG. 1** is one embodiment of NASA-sponsored "Highway in the Sky" (HITS) display format which is intended to improve the safety and ease of GA flying;

[0032] **FIG. 2** illustrates a conventional top-down display commonly used with a known Traffic Alert Collision Avoidance System (TCAS) navigation display;

[0033] **FIG. 3** illustrates by example and without limitation the integrated display presentation of the present invention embodied as an integrated cockpit display;

[0034] **FIG. 4A** by example and without limitation conformal lateral path and lateral path deviation cues of the invention viewed on approach at a first further distance from a runway;

[0035] **FIG. 4B** by example and without limitation the conformal lateral path and lateral path deviation cues of **FIG. 4A** viewed on approach at a second closer distance from a runway;

[0036] **FIG. 4C** by example and without limitation conventional lateral path and lateral path deviation cues presented on the integrated display presentation of the invention viewed on approach to a runway; and

[0037] **FIG. 5** illustrates by example and without limitation the integrated display presentation system of the invention embodied as a system block diagram for tactical flight path management in an aircraft environment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0038] In the Figures, like numerals indicate like elements.

[0039] The present invention is an apparatus and method for an integrated display presentation for tactical flight path management that simplifies instrument flight and makes it more like visual flight by replicating many of the cues basic to visual flight by integrating visual cues using spatial flow, integrating navigation information using conformal symbology, and improving instrumentation using an enhanced "T" instrument display.

[0040] Briefly, spatial flow is a graphical presentation technique that replicates one or more of the spatial motion and energy cues available in visual flying. Conformal symbology integrates navigation information using pre-attentive referencing by constructing visual depictions symbolic of ground-based phenomena, waypoints and other data as to conform to a view from the aircraft's cockpit. Conformal symbology optionally includes intruder aircraft and collision avoidance information supplied by a TCAS (Traffic Alert Collision Avoidance System) or ACAS (Airborne Collision Avoidance System) or another aerial traffic detection and collision avoidance system. Conformal symbology is rendered either using true one-to-one mapping, or using conformal compressed symbology in which the information is rendered using mapping that is not a true one-to-one mapping whereby the information on the display is maximized.

[0041] The enhanced "T" instrument display replicates and improves the instruments that are found in the pilot's basic "T" configuration provided by conventional displays. The basic data parameters available in the standard electromechanical "T" configuration include: airspeed, attitude, altitude, turn coordination, heading, and vertical speed. The enhanced "T" instrument display of the invention provides these and other previously demonstrated symbology elements developed for jet cockpits that are now affordable for GA, e.g., a pitch limit indicator, and supplemented with new concepts developed specifically for the GA marketplace, e.g., Virtual VASI which is described in detail herein and in co-pending U.S. patent application Ser. No. 10/052,716, entitled SIMULATED VISUAL GLIDESLOPE INDICATOR ON AIRCRAFT DISPLAY, which is incorporated by reference herein.

[0042] **FIG. 3** illustrates by example and without limitation the integrated display presentation of the present invention embodied as an integrated cockpit display **100**. The invention embodied as the integrated display **100** addresses the safety issues raised by the human factor limitations of the HITS technology, as discussed above, that include a requirement of storing a 3-D flight plan, clutter, cognitive tunneling and complacency. The integrated display presentation of the present invention embodied as the integrated display **100** addresses these safety issues by providing a seamless interface from take-off through landing that is independent of a stored 3-D flight plan, which is a known limitation of the HITS technology. The cues provided by the integrated display presentation of the invention provide consistent lateral and vertical guidance, regardless of distance from the desired flight path. A pilot is thereby ensured to have consistent flight path guidance, even when the pilot is significantly off path, which is when path guidance is most required.

[0043] **FIG. 3** illustrates the integrated display presentation of the invention embodied as the cockpit display **100** that replicates many of the cues basic to visual flight using spatial flow, conformal symbology, and enhanced "T" instrument display. The cockpit display **100** is by example and without limitation a graphical cockpit display embodied, for example, as a Primary Flight Display (PFD) **100**. A suitable head-down PFD is the Honeywell DU-1080 Display Unit, which is a color active matrix liquid crystal display based device 10.4" diagonal in size which is available from Honeywell International, Inc. of Morristown, N.J. Alternatively, the integrated display presentation for tactical flight path management of the invention is displayed on a Head-Up Display (HUD), which is, for example, the HUD2020 also available from Honeywell International, Inc. Many other displays are also suitable for practicing the integrated display and integrated display presentation of the invention; the Honeywell DU-1080 Display Unit and HU2020 unit

being only examples used to demonstrate the invention and not intended in any way to limit the scope of the invention. As discussed and illustrated herein the integrated display presentation of the invention is not limited to the integrated display embodiment illustrated in **FIG. 3**, but is alternatively embodied in one or more alternative cockpit displays that also replicate cues basic to visual flight using spatial flow, conformal symbology, and enhanced "T" instrumentation display technology of the invention.

[0044] Spatial Flow

[0045] An ability of the pilot to perceive spatial relationships is understood to be critical to the safety of flight. Spatial flow is a graphical presentation technique that replicates the spatial motion and energy cues available in visual flying. During visual flight, pilots perceive movement and distance by combining evidence about texture, perspective, and color changes. These same immergent features: texture, perspective, and color, are recreated and integrated in the cockpit display **100** by the integrated display presentation of the invention being operated by onboard automation. The spatial flow symbology elements provided on the cockpit display **100** by the integrated display presentation of the invention include an expanded vertical and horizontal field of view (FOV) relative to the narrow horizontal and vertical field of view presented by the HITS technology as shown in **FIG. 1**. The spatial flow symbology elements provided by the integrated display presentation of the invention also include color shading of sky **102** portion of the display **100** in shades of blue (color not shown) and the ground **104** portion in shades of brown or green or both (color not shown), as well as one or more optional random terrain texturing cues **105** superimposed on top of the colored ground. Horizontal and longitudinal perspective line segments **106** are superimposed on the ground portion **104**. A top one of the horizontal line segments **106** is symbolic of a horizon **107** that separates the sky and ground portions **102, 104**. Color gradations displayed in the sky portion **102** (illustrated as shading increasing toward the ground portion **104**) replicate color gradations in the sky on a clear blue day and thereby facilitate pre-attentive processing for depth perception, as well as indications for unusual attitude recovery. Perspective lines **106** on the ground portion **104** and color shading that increases toward the horizon **107** assist depth perception.

[0046] The integrated picture of cues of texture, perspective, and color provided by the integrated display presentation of the invention on the cockpit display **100** reproduce "optical flow," which can be defined as momentary velocity of one or more of texture and grid lines across the visual field that the pilot perceives close to the ground. Optical flow is achieved by regularly sampling the navigation data signals and using the updated information to update the positions of the terrain cues **105** and perspective lines **106** on the display presentation. The terrain cues **105** and perspective lines **106** are thus moved over the display screen at a rate that simulates the aircraft's changing position with respect to the ground. The relative positions of the terrain cues **105** and perspective lines **106** can be updated as a function of either the airspeed or position information. The optical flow thus reproduced by the invention on the display **100** improves situational awareness (SA), which can be defined as perception of elements in the environment within a volume of time and space and the projection of their status in the near future. The pilot is thereby better able to form a mental model of the current and projected states of the external flight environment.

[0047] A peripheral field is reported to be superior to central vision for the mediation of self motion or "vection." The expanded field of view provided by the "spatial flow" technology of the invention as operated by the onboard automation and presented on the display **100** thus provides valuable peripheral motion feedback which permits periphery detection, and thereby assists pilot performance and reaction time to an attitude upset. The peripheral field provided by the invention's expanded vertical and horizontal FOV is therefore superior to the more limited central vision of the HITS technology, which may remove meaningful motion cues, such as intruding aircraft, from the pilot's peripheral view. The expanded vertical and horizontal FOV provided on the display **100** is, however, limited to avoid becoming too distracting or creating a scan area too large to be comfortably viewed. Accordingly, based upon pilot feedback an appropriate expanded FOV is about 20 or 25 to about 45 or as much as about 60 degrees in the horizontal by 15 to 20 or 30 degrees in the vertical. The vertical FOV is optionally about one half the angle of the horizontal FOV. For example, according to one embodiment of the invention, the information is rendered on the display **100** using true one-to-one mapping whereby the FOV about 25 degrees or +/−12.5 degrees in the lateral and 13 degrees or +/−6.5 degrees in the vertical. According to another embodiment of the invention, the information is rendered on the display **100** using compressed mapping whereby the FOV about 45 degrees or +/−22.5 degrees in the lateral and 24 degrees or +/−12 degrees in the vertical.

[0048] The upper vertical portion of the generally rectangular FOV includes an arcuate or curved portion **108** that outlines and highlights the conventional roll scale **109** and generates a "keyhole" effect for the display **100**.

[0049] Conformal Symbology

[0050] Outside relationships are replicated on the head-down or head-up flight display **100** inside the aircraft via conformal symbology, whereby navigation information is integrated and positioned on the display **100** to appear in positions consistent with a view as seen on from the cockpit. Conformal symbology is rendered either using true one-to-one mapping, or using conformal compressed symbology as discussed herein. The invention thereby presents visual cues in a "real world" context while flying IFR on a PFD, similar to that experienced flying VFR. Presentation of conformal symbology on the cockpit display **100** has led to demonstrated improvement in overall SA. Conformal symbology permits the pilot to utilize pre-attentive referencing, which is a recognition driven process that reduces pilot workload, rather than requiring conscious decision. Tracking performance has been shown to improve when conformal symbology is used to present navigation information.

[0051] According to the present invention, conformal symbology elements include without limitation: a conventional runway/airport symbol **110**, lateral path and deviation indicator symbols **112, 114**, and conventional lateral current and next waypoint symbols **116, 118**. The conformal symbology of the present invention as embodied in the integrated display **100** reduces pilot workload, particularly close to the ground, by removing ambiguity of objects in the far

domain, i.e., the external world, that exist in instrument conditions by presenting those objects in the near domain, i.e., the display **100**, in positions consistent with a view as seen on from the cockpit. The conformal display symbology of the invention further aids pilots in the transition from near domain to far domain by presenting the information using symbology that mimics the form of the objects as they appear in the far domain. For example the virtual rising runway symbol **110** illustrates by example and without limitation the conformal display symbology of the invention presented on the cockpit display **100**.

[0052] Enhanced "T"

[0053] The enhanced "T" replicates and improves the instruments that are found in the pilot's basic "T" provided in conventional displays. The basic data parameters available in the standard electromechanical "T" configuration include: airspeed, attitude, altitude, turn coordinator, heading, and vertical speed. These data are presented in the basic "T" configuration using conventional analog needle displays and digital readouts. A traditional "T" configuration thus provides the pilot with data.

[0054] The enhanced "T" configuration of the present invention also provides the airspeed, attitude, altitude, turn coordinator, heading, and vertical speed data. The enhanced "T" configuration includes by example and without limitation an indicated air speed indicator **120** configured as a scale or tape having a pointer **122** showing the current indicated air speed and an airspeed trend indicator **124**; a conventional ball/attitude indicator **126**; and an altitude indicator **128** configured as a scale or tape and having a pointer **130** showing the current aircraft altitude, and an altitude trend indicator **132**. A conventional heading pointer on a compass rose (not shown) may be provided and may be supplemented by a digital readout of heading angle. A vertical speed trend indicator may be provided by an optional pictographic information display **134** using an arrow or other pointer mechanism **136**. The pictographic information display **134** may also display true air speed as well as additional information about the operational mode of the aircraft. The pictographic information display **134** is a new element provided on the display **100** and is described more completely in co-pending patent application Ser. No. ______ (Attorney Docket Number H0001712), entitled PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT, which is incorporated herein by reference.

[0055] The enhanced "T" configuration of the present invention replicates and improves the traditional "T" configuration by providing the pilot with information and "real world" context, modeling some display elements after those in modern commercial jet aircraft. **FIG. 3** also illustrates without limitation examples of the enhanced "T" technology that enhance the traditional "T" configuration. One example of the enhanced "T" illustrated in **FIG. 3** is a conformal pitch limit indicator (PLI) **138** embodied as a graphic indicator of the point of stall warning for the aircraft on a pitch scale **140** or a conventional pitch reference **142**. The display may include a conventional flight path vector **144** and flight path vector director **146**. Another new element presented on the display **100** is a simulation of an airport lighting aid configured as a simulated visual glideslope information display **148** on the cockpit display. The simulated visual glideslope information display **148**, which takes the form of a Precision Approach Path Indicator (PAPI) or Visual Approach Slope Indicator (VASI), is described more completely in co-pending U.S. patent application Ser. No. 10/052,716, entitled SIMULATED VISUAL GLIDESLOPE INDICATOR ON AIRCRAFT DISPLAY, which is incorporated herein by reference.

[0056] The basic principle of the simulated visual glideslope is that of monochromatic scaling. By example and without limitation, four indicators are arranged so that the pilot using the simulated visual glideslope during an approach sees the combination of indicators shown in **FIG. 3**. Depending on descent angle, the indicators appear either black or white. If the aircraft glideslope is too low all the indicators appear black, if it is too high, all indicators appear white. The indicators appear in shades of gray when slightly off an ideal approach path. When correctly on path, the top indicators appear black and the bottom indicators appear white.

[0057] Alternatively, the simulated visual glideslope information display **148** is implemented using red and white indicators with scaling in one or more shades of pink when slightly off an ideal approach path. When correctly on path, the top indicators appear red while the bottom indicators appear white.

[0058] The simulated visual glideslope path information display **148** also provides between the upper and lower pairs of indicators an ideal glideslope target **148***a* shown by example and without limitation as a white or other colored diamond indicator. The simulated visual glideslope information display **148** thus provides a qualitative indication of the aircraft's deviation above or below the ideal glideslope. The simulated visual glideslope information display **148** also enhanced by a vertical deviation indicator bar **148***b*, that is programmed to simulate a traditional vertical deviation scale, and thereby provide additional information as to the degree of deviation. The indicator bar **148***b* of the simulated visual glideslope information display **148** thus indicates to the pilot the amount and direction of change in altitude, either higher or lower, to increase the degree of coincidence with the glideslope. The simulated visual glideslope information display **148** thus provides the perceptual airport lighting aid information and leverages the advanced display **100** to integrate the cue with the vertical deviation bar.

[0059] In **FIG. 3** the column of indicators and the vertical deviation indicator bar **148***b* of the simulated visual glideslope information display **148** indicate the aircraft is slightly below ideal glideslope. The top indicators appear dark and the bottom indicators appears white, but the upper bottom indicator is shaded, i.e., scaled between the white and the dark color of the upper indicators. Also, the vertical deviation indicator bar **148***b* is below the ideal glideslope target **148***a*.

[0060] According to the invention as illustrated in **FIG. 3**, the enhanced "T" technology of the invention also provides on the display **100** another display portion **150** at the top of the screen or in another convenient location. The display portion **150** includes by example and without limitation the pictographic display **134** as well as an air speed readout **152**, an altitude readout **154**, and other information.

[0061] The enhanced "T" technology of the invention is also provided as a dynamic display presentation whereby

one or more of the different information displays, including for example and without limitation the information displays of airspeed **120**, air speed readout **152**, attitude, altitude **126**, altitude readout **154**, heading, and vertical speed, are dynamically presented in a context sensitive manner. One or more of the pictographic display **134** and the airport lighting aid simulation display **148** may be displayed dynamically as well.

[0062] According to the enhanced "T" portion of the invention, the dynamic presentation of the instrument displays is context sensitive, whereby different ones of the information displays are dynamically emphasized as a predetermined function of the current mode or phase of flight. The emphasis is provided to draw the pilot's attention to the information particularly relevant to the current phase of flight, e.g., taxi, take off, cruising, approach, landing and ground phases of flight or the current mode of flight, e.g., vertical speed (VS), indicated air speed (IAS), flight path angle (FPA), vertical navigation (VNAV), altitude hold (ALT), flight level change (FLCH) modes of flight, as well as the numerous other control parameters involving air craft attitude, speed, and thrust settings. Accordingly, a predetermined one or more of the different information displays is dynamically emphasized as a function of mode or phase of flight, with different ones of the information displays being emphasized during different modes or phases of flight. At about the time each different mode or phase of flight is entered, one or more of the information displays relevant to the respective mode or phase of flight is caused by the invention to metamorphose, i.e., the information displays strikingly transform its appearance, so as to draw the pilot's attention to an instrument reporting a flight parameter that is important or even critical during the current mode or phase of flight.

[0063] For example, the vertical speed area of the pictographic display **134** is dynamically emphasized while the aircraft is operating in the vertical speed (VS) mode as is a vertical speed indicator, if available. In another example, the altitude (ALT) information display area **128** is emphasized during an altitude mode of operation, such as closing on minimum descent altitude or minimum descent height (MDH) or off altitude operation.

[0064] The dynamic operation of the different information displays is of a predetermined character. For example, the different information displays are emphasized by metamorphosis or transformation in appearance using any of an animated size, font, shading and texture. The animated size emphasis is produced by increasing the size of the information display on the display **100** by an amount that will bring it to the pilot's attention, by example and without limitation a 20 percent size increase is used. For example, the altitude indicator **128** is increased in size on the display **100** by 20 percent during an altitude mode of operation, such as off altitude operation. The animated font emphasis is produced by increasing the font size in the indicator area by an amount that will bring it to the pilot's attention, by example and without limitation a 20 percent size increase is used. Additionally, the font color is optionally changed from a neutral color to amber, as a warning indication, or red, as a critical warning indication, as permitted by the FAA.

[0065] The animated shade emphasis is also produced by increasing the shade or color of the information display on the display **100** by an amount that will bring it to the pilot's attention. By example and without limitation a color change from white to yellow or red is used. For example, the color of the vertical speed area in the pictograph **134** is shaded from a neutral color such as green or white to yellow on the display **100** when the aircraft is operating in a vertical speed (VS) mode of flight. Additionally, the emphasis is optionally produced using texture metamorphosis or transformation, whereby the texture of an information display is emphasized by changing texture of the information display on the display **100**. For example, the texture of an information display is elevated from dashed or dotted to solid line during either of a mode or phase of flight during which that particular information display is critical.

[0066] The invention is further operated to emphasize on the display **100** different ones of the information displays as a function of cautionary or critical situations in a manner that will bring it to the pilot's attention using, by example and without limitation, a change in color from a neutral color to a cautionary or danger color. For example, the vertical speed area of the pictographic information display **134** providing vertical speed (VS) information is emphasized during an over speed or low speed condition by shading the color from a neutral green or white to a cautionary yellow or a danger red. In another example, the flight path angle (FPA) area of the pictographic information display **134** is emphasized during an off path situation on approach by shading the color from a neutral green or white to yellow or red. In yet another example, disturbance to intended attitude and path permits a pilot to detect windshear early so that an unrecoverable condition is less likely to occur. Thus, when disturbance to one or both the intended attitude and path is detected, one or both of the attitude indicator **126** and flight path angle (FPA) area of the pictographic information display **134** are metamorphosed or transformed dynamically to draw the pilot's attention. The dynamic metamorphosis of the one or more information displays on the display **100** is provided by an emphasis of one or more of display size, font, color and texture. Flight safety is thus improved.

[0067] In yet another example, an information display is emphasized by its sudden appearance on the display **100**. For example and without limitation, the simulated airport lighting aid **148** is absent from the display **100** during normal operation of the aircraft, only appearing during approach. The dynamic metamorphosis of the one or more information displays on the display **100** is provided by an appearance on the display **100** during an appropriate mode or phase of flight.

[0068] Among the outside relationships replicated on the PFD **100** inside the aircraft via the conformal symbology aspect of the invention, TCAS or ACAS (Airborne Collision Avoidance System) and to all aerial traffic detection and collision avoidance system information, such as Traffic Alert Collision Avoidance System (TCAS) or Airborne Collision Avoidance System (ACAS) navigation information, is integrated and positioned on the display **100** to appear in positions consistent with a view as seen on from the cockpit. The invention thereby presents visual aerial traffic cues in a "real world" context while flying IFR on a head-down or head-up display, similar to that experienced flying VFR. Accordingly, **FIG. 3** also illustrates by example and without limitation an optional conformal TCAS or ACAS navigation

display which may be provided in a wide-angle look-ahead view in contrast to the top-down view provided in conventional TCAS displays.

[0069] As described by U.S. Pat. No. 4,855,748, which is incorporated herein by reference, TCAS is a direction finding antenna system for determining the relative bearing of an intruding aircraft from a protected aircraft. TCAS equipment located aboard a protected aircraft periodically transmits interrogation signals that are received by reporting transponders located aboard intruding aircraft in the vicinity of the protected aircraft. The transponder of the intruding aircraft transmits a signal which reports its altitude. The TCAS equipment computes the range of the intruding aircraft by using the round-trip time between the transmission of the interrogation and the receipt of the reply. The TCAS equipment may also provide relative bearing information.

[0070] Altitude, altitude rate, range and range rate, and relative bearing are determined by tracking the reply information. These data, together with the current TCAS sensitivity level, which specifies the protected volume around the aircraft, are used to determine whether the intruding aircraft is a threat. Each threat aircraft is processed individually to permit selection of the minimum safe resolution advisory based on track data and coordination with other TCAS-equipped aircraft.

[0071] **FIG. 3** illustrates the wide-angle look-ahead conformal view of TCAS information provided by the integrated display **100** of the invention. According to the present invention, the integrated display **100** of the invention is coupled to receive the TCAS information and is structured to isolate that portion of the information that lies within the scope of the illustration of the real world provided on the display **100**. In other words, the invention determines that portion or "slice" of the TCAS information relevant to the wedge shaped field of view (FOV) encompassed by the integrated display **100** of the invention. The invention isolates this relevant portion of the TCAS information and operates as a repeater to displays it to the pilot. Thus, any intruding aircraft approaching the protected host aircraft within the range of the onboard TCAS equipment is detected by the TCAS equipment. The integrated display **100** of the invention receives the information and determines which, if any, of the intruding aircraft are within the horizontal and vertical FOV presented by the integrated display **100** of the invention. The invention reduces the 3-dimensional traffic data into a 2-dimensional wide-angle look-ahead view and presents the information conformally superimposed with the sky and ground portions **102, 104**. Thus, the intruder aircraft appear on the display **100** at approximately the same positions relative to the aircraft as they would appear, if visible, through the cockpit windscreen.

[0072] Conventional horizontal display symbology and processes are utilized to depict the intruding aircraft, thereby maximizing commonality and avoiding costly retraining of flight crews to interpret data in a new fashion. Furthermore, the method and circuit of the invention are applicable to TCAS or ACAS (Airborne Collision Avoidance System) and to all aerial traffic detection and collision avoidance systems.

[0073] An assumption of the traditional horizontal or top-down representation (shown in **FIG. 2**) is that many aircraft are being flown in level horizontal planes. However, the probability of an intruding aircraft being exactly on a given horizontal plane is quite small. Therefore, the integrated display **100** of the invention incorporates into the look-ahead representation **200** of TCAS data a vertical element of the 3-dimensional traffic data. Thus, the 3-dimensional sampling volume traffic data is depicted as compressed into a vertical plane as seen through the cockpit windscreen. Any intruder aircraft lying within the 3-dimensional sampling volume of the onboard TCAS equipment and within the FOV of the protected host aircraft represented by the integrated display **100** of the invention are represented as lying within that planar FOV, as shown by intruder aircraft tags circle **202**, square **204**, and diamond **206**. Other intruder aircraft lying within the 3-dimensional sampling volume but outside the particular FOV represented by the integrated display **100** are not represented.

[0074] Preferably, commonality with current TCAS systems is maximized, thereby avoiding retraining of flight crews to learn to interpret data in a new fashion. Other symbology is similarly contemplated, and although perhaps not as familiar to the flight crew trained to use conventional horizontal profile displays, are considered to be within the scope of the invention. Therefore, the invention preferably uses current TCAS symbology to represent an intruder. Accordingly, similar to circle **32** (shown in **FIG. 2**), circle **202** colored amber represents an intruder entering the alert zone and suggests a moderate threat to the protected host aircraft recommending preparation for intruder avoidance. Similar to square **30** (shown in **FIG. 2**), square **204** colored red represents an intruder entering warning zone and suggests an immediate threat to the host aircraft with prompt action being required to avoid the intruder. Diamond **206**, similar to diamond **34** (shown in **FIG. 2**) represents near or "proximate traffic" when colored solid blue or white and represents more remote traffic or "other traffic" when represented as an open blue or white diamond. Air traffic represented by either solid or open diamond **206** is "on file" and being tracked by the TCAS similar to diamond **34**.

[0075] Similar to the description in **FIG. 2**, each indicia or tag **202, 204, 206** is accompanied by a two digit number preceded by a plus or minus sign. In the illustration of **FIG. 3** for example, a "+05" is adjacent square tag **204**, a "−03" is adjacent circle tag **202** and a "−12" is adjacent diamond tag **206**. Each tag may also have an vertical arrow pointing either up or down relative to the display. The two digit number represents the relative altitude difference between the host aircraft and the intruder aircraft; the plus and minus signs indicating whether the intruder is above or below the host aircraft. Additionally, the two digit number appears positioned above or below the associated tag to provide a visual cue as to the intruder aircraft's relative position: the number positioned above the tag indicates that the intruder is above the host aircraft and the number positioned below the tag indicates that the intruder is below the host aircraft. The associated vertical arrow indicates the intruder aircraft's altitude is changing at a rate in excess of 500 feet per minute in the direction the arrow is pointing. The absence of an arrow indicates that the intruder is not changing altitude at a rate greater than 500 feet per minute.

[0076] Depiction of Potentially Corrective Action

[0077] If the treat detection logic in the TCAS computer determines that a proximate aircraft represents a potential collision or near-miss encounter, the computer threat reso-

lution logic determines the appropriate vertical dive or climb maneuver that will ensure the safe separation of the TCAS aircraft. The appropriate maneuver is one that ensure adequate vertical separation while causing the least deviation of the TCAS aircraft from its current vertical rate.

[0078] As discussed above, the TCAS described in the RTCA/DO-185 document provides advisories only for vertical maneuvers of the protected aircraft to escape collision with a threat aircraft. U.S. Pat. No. 4,855,748 provides an improved TCAS that provides advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers, thereby further reducing the probability of collision. When the protected host aircraft is provided with the improved four-antenna TCAS system as taught by U.S. Pat. No. 4,855,748, the TCAS equipment provides and utilizes knowledge of the relative bearing of the intruding aircraft from the protected aircraft, in addition to the other data normally collected by standard TCAS equipment, to provide advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers.

[0079] The integrated display **100** of the invention may also include one or more areas represented by rectangular boxes **208, 210, 212, 214, 216** which are areas reserved for word text displays wherein conditions of the TCAS are reported to the pilot of the host aircraft. For example, if a portion or component of the TCAS fails, a concise textual report describing the failure appears in one of rectangular boxes **208, 210, 212, 214, 216**. In another example, if the operator operates the mode control **46** of the TCAS (shown in **FIG. 2**) to select one of a limited number of operational modes, a concise textual message indicating the choice of operational mode appears in another of rectangular boxes **208, 210, 212, 214, 216**. The selectable operational modes are described above and typically include a "standby" mode in which both of the host aircraft transponder systems are inactive, a "transponder on" mode in which a selected one of primary transponder and secondary transponder is active, a "traffic alert" mode in which an alert is transmitted to the protected host aircraft pilot if any Mode-C or Mode-S transponder equipped aircraft are entering a first predetermined cautionary envelope of airspace, and a "traffic alert/resolution advisory" mode in which a traffic alert (TA) and/or resolution advisory (RA) is issued if any Mode-C or Mode-S transponder equipped aircraft are entering a second predetermined warning envelope of airspace.

[0080] **FIGS. 4A and 4B** illustrate by example and without limitation a course deviation indicator utilizing the conformal lateral deviation indicator cues **112** of the invention and the conformal lateral path indication cues **114** of the invention on approach. The Figures illustrate the invention at different first further (cues **112***a* of **FIG. 4A**) and second closer (cues **112***b* of **FIG. 4B**) distances from the ground. One embodiment of the invention uses two deviation marks located on each side of the runway centerline. During an ILS (Instrument Landing System) approach each mark represents 1.75 degrees lateral separation. Full scale sensitivity of the course deviation indicator is 5 degrees or 2.5 deg each side. On a VOR approach (a VHF Omnidirectional Radio Range ground-based navigation device that provides bearing information to an aircraft) each mark represents 5 degrees lateral separation for a full scale of 10 degrees each side and a total radial span of 20 degrees.

[0081] As illustrated in **FIGS. 4A and 4B**, the conformal lateral deviation indicator cues **112** increase in apparent size and spread apart as the host aircraft approaches the ground more closely. The lateral deviation marks provide a scale for determining the lateral deviation from the course or centerline. The deviation marks also convey intuitive altitude information. At high altitudes the deviation marks are displayed close together. As altitude decreases, the deviation marks spread apart, just as if they were actually drawn on the earth. The conformal lateral deviation indicator cues **112** of the invention thus mimic lateral deviation cues on the target runway, if such were visible. The lateral deviation marks thereby provide an intuitive display to communicate three dimensional situational data to a pilot, simplify aircraft navigation, reduce pilot workload and increase aircraft safety.

[0082] The means of forming the conformal lateral deviation indicator cues **112** are generally well-known and are described by Uhlenhop and Wilkens in U.S. Pat. No. 5,745,863, entitled THREE DIMENSIONAL LATERAL DISPLACEMENT DISPLAY SYMBOLOGY WHICH IS CONFORMAL TO THE EARTH, issued on Apr. 28, 1998, which is owned by the assignee of the present application and the entirety of which is incorporated herein by reference. The conformal lateral path indication cues **114** of the invention are formed using similar means.

[0083] U.S. Pat. No. 5,745,863 discloses an aircraft display which communicates three dimensional lateral information to a pilot of the aircraft. An extended course centerline symbol and lateral deviation marks indicate lateral deviation from a desired course along with approximate altitude and distance-to-go information to the pilot. The course centerline extends toward a vanishing point near the horizon line, as illustrated in **FIG. 3**. The centerline symbol swings laterally across the display responsive to changes in lateral deviation of the aircraft such that an intuitive perspective view is provided to the pilot. Lateral deviation marks similar to those shown in **FIGS. 3, 4A** and **4B** provide precise lateral deviation information to the pilot.

[0084] U.S. Pat. No. 5,745,863 discloses using available navigation data to compute and then display a course centerline which extends toward a vanishing point near the horizon line of the display. The centerline symbol simulates a course centerline drawn on the earth's surface, hence the term "conformal." According to the present invention, the conformal lateral path indication cue **114** is also displayed in a perspective view, thereby providing a conformal centerline.

[0085] During the approach phase of flight the present invention provides the conformal lateral path indication cue **114** along the approach path. At high altitudes large lateral movement of the aircraft is required to move the position of the conformal lateral path indication cue **114**, while at low altitudes much smaller lateral movement of the aircraft is required to make an equivalent move of the conformal lateral path indication cue **114**.

[0086] U.S. Pat. No. 5,745,863 discloses simulating the earth surface as a flat surface 2000 feet below cruise altitude. During approach the earth surface is thus simulated as a flat surface at the same altitude as the destination runway.

[0087] **FIG. 4C** illustrates by example and without limitation conventional lateral deviation indicator cues **112***c*

utilized with conventional flight displays. The conventional lateral deviation indicator cues **112c** are optionally substituted in the presentation of the invention for the conformal lateral deviation indicator cues **112** of the invention.

[0088] **FIG. 5** illustrates by example and without limitation an integrated display presentation system **300** of the invention for tactical flight path management in an aircraft environment embodied as a system block diagram. Accordingly, various signals are provided to the integrated display presentation system **300** of the invention for generating and displaying the integrated display presentation of the invention, including the spatial flow symbology, the conformal symbology, and the enhanced "T" instrument information on the cockpit display **100** shown in **FIG. 3** or another suitable head-down or head-up cockpit display device.

[0089] The integrated display presentation of the invention is provided as a set of machine instructions received and operated by the onboard automation and presented on the integrated display **100**. The machine instructions include instructions for receiving data from one or more of the instrument information signals available on either an aircraft data bus **302** or another suitable means for providing real-time electronic signal data source of instrument signals reporting flight parameter information provides the various signals to the integrated display presentation system **300** of the invention. A detailed description of the signals available on an aircraft data bus **302** is provided by the ARINC Characteristic **429** as published by Aeronautical Radio, Incorporated of Annapolis, Md., the entirety of which is incorporated herein by reference. Included among the signals provided by the aircraft data bus **302** or other suitable source are signals useful for operating the integrated display presentation system **300** of the invention, these signals including by example and without limitation: barometric and radio altitude signals; a vertical speed signal: an air speed signal; navigation signals including GPS altitude, course, heading, latitude and longitude signals; autopilot signals; a radio glideslope signal; flap and gear position signals; pitch indicator signals; localizer receiver signals; and collision avoidance signals.

[0090] These signals are used as inputs to an integrated display presentation circuit, which in turn is effective to generate an integrated plurality of display control signals informing the different display presentations of the invention. The integrated plurality of display control signals are applied to a display generator, that in turn generates a plurality of display control signals that result in the spatial flow symbology, conformal symbology, and enhanced "T" instrument information being displayed on the cockpit display **100**.

[0091] A plurality of machine instructions are stored in an onboard memory **304**, which are retrieved and operated by a computer processor **306** to generate the integrated display control signals for generating the integrated display presentation of the invention. The computer processor **306** is for example but without limitation a microprocessor, a digital signal processor, or another suitable processor and may be either a dedicated processor or a processor shared with other onboard equipment. The processor **306** includes inputs coupled to the onboard memory **304** to receive machine instructions and inputs coupled to the data bus **302** to receive sources of instrument signals reporting flight parameter information. The processor **306** uses data received from a navigation system **308** on the aircraft to provide current information about the altitude, course, heading, latitude and longitude of the aircraft. The navigation data may be obtained directly from the navigation system, which may include an inertial navigation system, a satellite navigation receiver such as a GPS receiver, VLF/OMEGA, Loran C, VOR/DME or DME/DME, or from a Flight Management System (FMS).

[0092] Information about the barometric altitude, vertical speed and air speed of the aircraft are available from the navigation system **308**, from an air data computer **310**, or from a barometric altimeter and a barometric rate circuit present on the aircraft. The vertical speed may be expressed as a barometric rate, or as Z velocity, which may be obtained from an onboard inertial navigation system. Alternatively, the simulated visual glideslope indicator system **300** utilizes altitude signals from a radio altimeter **312**. The altitude signals are optionally geometric altitude signals generated by the computer processor **306** as a blended combination of the instantaneous GPS altitude signal and the barometric altitude signal as described by Johnson et al. in U.S. Pat. No. 6,216,064, entitled METHOD AND APPARATUS FOR DETERMINING ALTITUDE, issued on Apr. 10, 2001, which is owned by the assignee of the present application and the entirety of which is incorporated herein by reference. Methods and apparatus for determining altitude, specifically altitude in an aircraft, and an estimated error of the altitude are described in U.S. Pat. No. 6,216,064. The altitude determination preferably uses a first altitude based on hydrostatic calculations, including local pressure and temperature, as well as a second altitude which is preferably a GPS altitude. Radio altimetry can also be used instead of or as a complement to the GPS altitude. Other sources of altitude determination can be used in the equation for the calculation of the final altitude. Each of the sources of altitude determination is provided with a complementary estimated error. In the final determination of the probable altitude, each source of altitude information is preferably accorded a weighting according to the estimated error of the altitude source. For global positioning altitude, the final combination of the altitude sources uses a complementary filter which takes into account the selective availability of the GPS altitude. This accounts for the long-term accuracy but short-term inaccuracy of GPS altitude. Corrections are provided to account for horizontal changes in pressure gradient as the aircraft moves from an origin to a destination. The invention described in U.S. Pat. No. 6,216,064 further provides for the altitude to be corrected based on non-standard atmospheric temperature (ISA) variations. In operating the method of U.S. Pat. No. 6,216,064, the computer processor **306** and memory **304** are configured to receive the altitude information and make the necessary calculations to result in an estimate of the current altitude which is then made available to the different operations performed by the integrated display presentation system **300** of the present invention. The computer processor **306** includes inputs to receive sources of altitude information.

[0093] A signal from a glideslope receiver **314** may be used to indicate whether an ILS is available to provide a glideslope radio signal. Discrete signals from discretes **316** and **318** indicate the position of the flaps and landing gear, which indicate whether the aircraft is configured for landing, and discrete signals from a pitch indicator discrete **319**

indicate the real time aircraft pitch angle. Also available are signals from a localizer receiver **320**, which indicate whether the aircraft is on a correct course for a landing.

[0094] Signals from the autopilot system **322** may be used to control the aircraft's flight characteristics. TCAS, ACAS or other collision avoidance system signals **324** are also available on the data bus **302** for providing aerial traffic detection and collision avoidance information.

[0095] A Flight Management System (FMS) **325** coupled to the data bus **302** has stored therein information about the intended course during the current flight, including information about the positions of waypoints along the aircraft's flight path.

[0096] These signals available on the data bus **302** are applied to the processor **306** for enabling the integrated display presentation of the invention according to the different ones of the spatial flow symbology presentation, the conformal symbology presentation, and the enhanced "T" instrument information presentation operations performed by the integrated display presentation system **300** of the invention.

[0097] A memory device **326** coupled to the processor **306** stores a plurality of databases of information relevant to performance of the different operations of the invention. A location search logic device **328** is coupled between the memory device **326** and the processor **306** for accessing one of the databases during performance of one or more of the different operations of the invention.

[0098] Using the data supplied by the different instrument and aerial traffic detection and collision avoidance information signals available on the data bus **302**, the processor **306** operates one or more algorithms for generating the plurality of display control signals, including the spatial flow symbology signals, conformal symbology signals, and enhanced "T" instrument information signals, as illustrated in **FIG. 3** and described in detail below. The display control signals are output to a display generator **330** that interprets the display control signal to generate the spatial flow symbology, conformal symbology, and enhanced "T" instrument information displays on the display **100**.

[0099] According to one embodiment of the invention, the integrated display presentation information of the invention, including the spatial flow symbology, conformal symbology, and enhanced "T" instrument information displays are displayed on the display **100**, which is embodied as a liquid crystal display (LCD). When the display **100** is embodied as a color LCD, the integrated display presentation information are displayed as described herein. However, when the display **100** is embodied as a black and white LCD, the integrated display presentation information are displayed in shades of gray, for example, as illustrated in Figures.

[0100] Spatial Flow

[0101] The integrated display presentation system **300** as embodied in **FIG. 5** includes a plurality of machine instructions stored in the onboard memory **304**, which are retrieved and operated by a processor **306** to generate the simulated visual field of view (FOV) on the display **100**. The processor **306** receives an altitude data signal from one of the altitude data signals sources on the data bus **302** to provide current information about the altitude of the aircraft. The altitude data are applied to the processor **306** for enabling the expanded FOV, including the horizon **107**.

[0102] An additional plurality of machine instructions stored in the onboard memory **304** are retrieved and operated by the processor **306** to generate coloration of either or both the sky **102** and ground **104** when the display **100** is a color display, thereby assisting depth perception. Optionally, the machine instructions stored in the onboard memory **304** and retrieved by the processor **306** are operated to generate shading of either or both the sky **102** and ground **104** that increases toward the horizon **107**, thereby replicating color gradations in either or both the sky **102** and ground **104** that further assist depth perception.

[0103] Further machine instructions stored in the onboard memory **304** are retrieved and operated by the processor **306** to generate the horizontal and longitudinal perspective lines **106** superimposed on the ground **104**, the longitudinal perspective lines **106** converging to a common vanishing point on the horizon **107**, thereby further assisting depth perception.

[0104] Optionally, machine instructions stored in the onboard memory **304** are retrieved and operated by the processor **306** to generate the texture cues **105** superimposed on the ground **104**, which further assist depth perception. The texture cues **105** is either applied randomly or as a function of actual ground texture determined from a database **332** stored in the memory device **326** and containing terrain information as a function of position, such as a position defined by latitude and longitude values. In such instance, the processor **306** additionally retrieves real time position information available on the data bus **302** and, using the position information, retrieves terrain information as a function of the real time aircraft position and retrieves further terrain information as a function of the real time aircraft heading and projected along the heading even as far as the horizon **107** and the lateral extents of the FOV. The processor further optionally operates machine instructions retrieved from the memory **304** to superimpose the terrain texture cues **105** on the ground **104** as a function of real time altitude of the aircraft so that the terrain appears substantially as if viewed through the cockpit windshield. The randomly applied or real time terrain cues **105** is moved down toward the bottom of the screen of the display **100** to represent actual terrain moving past underneath the aircraft.

[0105] The processor **306** optionally retrieves real-time air speed information available on the data bus **302** and, using the air speed information, moves the terrain cues **105** over the display screen as a function of the real-time air speed of the aircraft. The aircraft air speed value used in moving the terrain cues **105** over the display screen is optionally a true air speed that is adjusted for wind effects to reflect actual speed over the ground.

[0106] The immergent features: texture, perspective, and color, are thus recreated and integrated in the cockpit display **100** by the integrated display presentation **300** of the invention being operated by the onboard processor **306**. The integrated picture of cues of texture, perspective, and color provided by the integrated display presentation **300** on the cockpit display **100** reproduce "optical flow," Which improves situational awareness SA.

[0107] Furthermore, according to the invention, any one or more of the different immergent features are optionally

recreated on the cockpit display **100** either independently or in combination one or both of the other immergent features. A degree of optical flow is thereby reproduced using minimal processing power.

[0108] Conformal Symbology

[0109] The integrated display presentation system **300** as embodied in **FIG. 5** includes a plurality of machine instructions stored in the onboard memory **304**, which are retrieved and operated by a processor **306** to generate simulated terrain object cues **105** on the display **100**, whereby outside relationships are replicated on the display **100** inside the aircraft. The simulated terrain object cues **105** are alternatively rendered on the display **100** using true one-to-one mapping or a compressed mapping that maximizes the amount of information presented on the display. The integrated display presentation system **300** thus presents terrain object information using symbology that substantially mimics the form of the objects as they appear in the far domain. In other words, the terrain object cues **105** are presented in positions consistent with a view of terrain as seen on from the cockpit, which the pilot to utilize pre-attentive referencing rather than conscious decision, thereby reducing pilot workload.

[0110] U.S. Pat. No. **5,745,863**, THREE DIMENSIONAL LATERAL DISPLACEMENT DISPLAY SYMBOLOGY WHICH IS CONFORMAL TO THE EARTH, which is incorporated herein by reference, illustrates well-known means for computing and implementing symbology conformal with the earth's surface. Those skilled in the art can readily adapt these calculations or use substantially similar calculations, including embodiments using satellite position and altitude systems such as the global positioning system(GPS) and the like, for computing and implementing the conformal symbology of the present invention. These calculations are straight forward using basic trigonometry, as disclosed in U.S. Pat. No. 5,745,863.

[0111] Accordingly, those of ordinary skill in the art can use generally well-known calculations adapted from or substantially similar to the calculations disclosed by U.S. Pat. No. 5,745,863 in combination with known aircraft position and altitude information (retrieved from onboard instruments) and known terrain position and altitude information (retrieved from a database) to compute and implement terrain symbology conformal with the earth's surface as it would appear from the cockpit if visible. Additional conformal symbology elements include without limitation: the conformal lateral deviation indicator cues **112**; the conformal lateral path indication cues **114**; the conformal lateral current and next waypoint cues **116, 118**, the conformal PLI (pitch limit indicator) cue **138**, e.g., the conformal pitch scale cue **140** or pitch reference **142**; and the conformal runway/airport symbol **110**. Well-known means similar to those used for computing and implementing the conformal terrain symbology of the invention are used for computing and implementing these additional conformal symbology elements of the present invention. Accordingly, those of ordinary skill in the art can use generally well-known calculations adapted from or substantially similar to the calculations disclosed by U.S. Pat. No. 5,745,863 in combination with known aircraft position and altitude information and other known information (retrieved from onboard databases or other onboard instruments) to compute and implement the additional conformal symbology elements of the present invention. These additional conformal symbology elements are also rendered on the display **100** using true one-to-one mapping or a compressed mapping that maximizes the amount of information presented on the display.

[0112] Furthermore, according to the present invention, any one or more of the plurality of different conformal symbology display control signals for presenting one or more of the plurality of different conformal symbology information displays, including one or more of the conformal lateral deviation indicator cues **112**, the conformal lateral path indication cues **114**, conformal visual landmarks such as the conformal lateral current and next waypoint cues **116, 118**, the conformal PLI cue **138**, and the conformal runway/airport symbol **110**, is optionally operated independently or in combination with any one or more of the other plurality of the different conformal symbology presentations. Thus, the different conformal symbology presentations can be presented on the display independently or in any combination with the other conformal symbology presentations within the integrated display presentation system **300**.

[0113] The processor **306** receives altitude and position data signals from respective altitude and position data signals sources on the data bus **302** to provide current information about the altitude, position, course and heading of the aircraft. The altitude and position data are applied to the processor **306** for enabling the conformal lateral deviation indicator and lateral path indicator cues **112, 114** relative to the aircraft's current position and the desired course along the ground.

[0114] The scale of the conformal lateral deviation indicator and lateral path indicator cues **112, 114** are presented relative to the aircraft's current altitude, the machine instructions thus drive the processor **306** to operate an algorithm for varying the scaling or distance between the conformal lateral deviation indicator trapezoids **112** as a function of the aircraft's estimated altitude above ground. Accordingly, as the aircraft approaches closer to the ground, the deviation indicator cues **112** and the distance between them become larger. The perspective view presented by the deviation indicator cues **112** also aids the pilot in recognizing distance to the airport, thereby assisting with subconscious pre-attentive referencing.

[0115] Visual landmarks, such as a mountain peak on the horizon, provide situation awareness by helping guide a pilot to a destination. When flying IMC, these landmarks are not available. The conformal lateral current and next waypoint cues **116, 118** substitute for such landmarks by replicating an element common to visual flight, thereby increasing SA and contributing to visual momentum.

[0116] Additional machine instructions stored in the memory **304** are operated by the processor **306** for enabling the conformal lateral current and next waypoint cues **116, 118** relative to the aircraft's current position and heading. Information for locating the current and next waypoints and the cues **116, 118** are stored in the aircraft's FMS device **325**. The machine instructions drive the processor **306** to access position and heading data available on the data bus **302** as well as positions of the current and next waypoints and to operate an algorithm for determining the positions of one or both of the lateral current and next waypoints relative to the aircraft's current position. The machine instructions further

drive the processor **306** to operate an algorithm for positioning in real time the lateral current and next waypoint cues **116, 118** conformally relative to the aircraft's current position and heading as a function of the relative positions of the lateral current and next waypoints. The machine instructions drive the processor **306** to vary the conformal positions of the lateral current and next waypoints as a function of the real time deviations from the current position and heading.

[0117] Spatial disorientation occurs when a pilot is deprived of visual references to determine the aircraft's orientation in space. Loss of directional control may occur if the pilot is not aware of the bounds of pitch, and a stall/spin or a stall/mush can be a deathly result. Around 50% of GA accidents can be attributable to lost control or the stall/spin/mush condition. The conformal PLI **138** provides visual cues to the approach of stall conditions and is thus a very salient cue that dramatically increases awareness of approach to stall condition and enhance safety.

[0118] Additional machine instructions stored in the memory **304** are operated by the processor **306** for enabling the conformal PLI **138** relative to the aircraft's current pitch. The machine instructions drive the processor **306** to access discrete pitch data available on the data bus **302** and to operate an algorithm for determining the aircraft's current pitch attitude. The machine instructions drive the processor **306** to vary the conformal PLI **138** as a function of the real time pitch indicator data. The conformal PLI **138** is presented conformally about the pitch ladder **140** or pitch scale **142** on the center of the display **100** having substantially the same attitude that a stick shaker, if present, would start to shake.

[0119] Furthermore, yet additional machine instructions stored in the memory **304** are operated by the processor **306** for enabling the conformal pitch tape or pitch scale **140** and horizon **107** relative to the aircraft's current pitch. The processor **306** is thus enabled for presenting the aircraft's conformal attitude on the display **100** whereby 1 degree on the display is substantially equal to 1 degree as viewed through the cockpit windscreen. The machine instructions drive the processor **306** to access discrete pitch data available on the data bus **302** and to operate an algorithm for determining the aircraft's current pitch attitude. The machine instructions drive the processor **306** to vary the conformal pitch scale **140** and horizon **107** as a function of the real time pitch data. The conformal pitch scale **138** and horizon **107** are presented conformally on the center of the display **100** having differently colored solid ticks for positive and negative pitch, e.g., light blue ticks for positive pitch and brown ticks for negative pitch. Additionally, the machine instructions drive the processor **306** to present markers on the horizon **107** at regular intervals. For example, light blue ticks are presented on the horizon **107** line at 10 degree intervals.

[0120] The ball/attitude indicator **126** is provided in as large an image as the display **100** permits. Larger displays permit a pilot to more easily discriminate upsets to pitch due to the increase in periphery field of view. When a pilot can quickly detect a disturbance, a corrective action can be quickly made, thereby improving overall performance, i.e., on track, on altitude, on speed performance. Overall workload is also reduced because the earlier a pilot catches a problem, the more quickly the problem can be resolved so that less cognitive and physical exertion is required to maintain overall performance. The conformal PLI **138**, pitch scale, pitch reference, and horizon cues **140, 142, 107** also greatly improve safety by providing early recognition so that the pilot is less likely to get into an unrecoverable condition. For example, in the example of windshear, if a pilot can detect it early by means of a disturbance to intended attitude and path, she can respond earlier and is therefore less likely to get into an unrecoverable condition. The use of conformal symbology thus provides visual momentum to out-the-window-view.

[0121] When in range of an airport, the conformal runway/airport cues **110** are presented on the display **100** to provide a means for pre-attentive referencing whereby the pilot workload is reduced by providing visual cues that permit the pilot to dispense with conscious decision making. Thus, additional machine instructions stored in the memory **304** are retrieved and operated by the processor **306** for enabling the conformal runway/airport cues **100** relative to the aircraft's current position, heading and altitude. The machine instructions drive the processor **306** to access position, heading and altitude data available on the data bus **302**. The machine instructions also drive the processor **306** to request airport and runway information from the location search logic circuit **328**. The location search logic **328** uses either the latitude and longitude data supplied by the navigation system **308** (shown) or information from the flight plan stored in the onboard FMS to access a database **334** of airport and runway information stored in the onboard memory **326**.

[0122] The machine instructions drive the processor **306** to operate an algorithm for determining the positions of the airport and runway relative to the aircraft's current position. The machine instructions further drive the processor **306** to operate an algorithm for generating the runway/airport cues **110** conformally as a function of altitude relative to the aircraft's current position and heading.

[0123] The machine instructions drive the processor **306** to generate the airport portion of the symbol **10** when the aircraft is above about 1,000 feet above ground level (AGL) because the airport's relative size makes it visible. As the aircraft approaches the ground, the machine instructions drive the processor **306** to generate the runway portion of the symbol **110**, and the airport portion is removed from the display. As discussed herein, the machine instructions drive the processor **306** to generate the conformal runway/airport symbol **110** using horizontal and longitudinal line segments to appear conformal to a flat surface on the ground. The algorithm operated by the processor **306** causes the longitudinal line segments to terminate at fixed depression angles which determine Y coordinates for the line end points. X coordinate end points of the longitudinal lines are based on a quantity commonly referred to as "inverse slope" so that if the longitudinal lines were extended, the end points would theoretically extend to a common vanishing point on the horizon **107** and to a point directly below the aircraft.

[0124] Furthermore, the machine instructions drive the processor **306** to regularly update the relative size and position of the airport and runway as a function of the aircraft's real time position, heading and altitude so that the runway/airport symbol **110** is sized and positioned on the

display **100** such that its image overlays the actual airport as seen from the pilot's position with the images presented on the display **100** substantially conforming to actual features on the ground as seen on approach from the aircraft's cockpit. The conformal display **100** assists with subconscious pre-attentive referencing and bypasses conscious decision making. The conformal display **100** has been shown to reduce pilot workload while improving pilot tracking performance.

[0125] The machine instructions thus drive the processor **306** to vary the conformal size and positions of the runway and airport cues **10** as a function of the real time changes in relative position, heading and altitude so as to present the airport and runway on the display **100** in their perceived position in depth and thereby replicate cues basic to visual flight.

[0126] Additional machine instructions stored in the memory **304** are operated by the processor **306** for enabling the conformal TCAS or ACAS aerial traffic detection and collision avoidance information relative to the aircraft's current position, heading and altitude.

[0127] The machine instructions drive the processor **306** to operate an algorithm for receiving current TCAS or ACAS aerial traffic detection and collision avoidance information from an onboard TCAS or ACAS equipment **336** that receives transponder signals from intruder aircraft via an antenna **338**. The machine instructions further drive the processor **306** to operate the algorithm for determining the positions of intruding aircraft relative to the protected host aircraft's current position, heading and altitude. The machine instructions further drive the processor **306** to operate an algorithm for isolating that portion of the information that lies within the scope of the illustration of the "real world" provided on the display **100**, i.e., that portion or "slice" of the TCAS information relevant to the wedge shaped field of view (FOV) encompassed by the integrated display **100** of the invention. The machine instructions further drive the processor **306** to operate an algorithm for generating the aerial traffic cues conformally as a function of altitude relative to the aircraft's current position and heading. For example, the algorithm generates each indicia or tag **202, 204, 206** that represents aerial traffic within the horizontal and vertical extents of the wedge shaped FOV presented by the integrated display **100** of the invention.

[0128] Well-known means adapted from or substantially similar to the calculations disclosed by U.S. Pat. No. 5,745,863 are used in combination with aircraft and aerial traffic information for computing and implementing the conformal aerial traffic symbology of the present invention. Accordingly, it is generally well-known to those of ordinary skill in the art to use generally well-known calculations in combination with known aircraft position and altitude information (retrieved from onboard instruments) and aerial traffic relative position and altitude information (retrieved from an aerial traffic detection and collision avoidance system such as TCAS or ACAS) to compute and implement aerial traffic symbology conformal with the earth's surface. The algorithm for rendering the TCAS information on the display **100** utilizes either true one-to-one mapping or the compressed mapping discussed herein that maximizes the amount of information presented on the display.

[0129] Using conventional TCAS threat level indicators, the threat level of each intruder aircraft within the FOV presented by the display **100** is also repeated in combination with the corresponding indicia or tag **202, 204, 206** that represents the intruder. Conventional TCAS symbology is also used to represent the relative altitude difference between the protected host aircraft and the intruder aircraft; whether the intruder is above or below the host aircraft; the two digit number that provides a visual cue as to the intruder aircraft's relative position; and the vertical arrow indicator of the intruder's altitude rate of change.

[0130] Furthermore, the machine instructions drive the processor **306** to regularly update the relative position of the aerial traffic detection and collision avoidance information as a function of the protected host aircraft's real time position, heading and altitude.

[0131] When the protected host aircraft is provided with the improved four-antenna TCAS system as taught by U.S. Pat. No. 4,855,748, the TCAS equipment provides and utilizes knowledge of the relative bearing of the intruding aircraft from the protected aircraft, in addition to the other data normally collected by standard TCAS equipment, to provide advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers. Additional machine instructions drive the processor **306** to repeat the TCAS advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers.

[0132] Other machine instructions drive the processor **306** to repeat the TCAS text displays wherein conditions of the TCAS are reported. The TCAS text displays are repeated in one or more of the areas represented by rectangular boxes **208, 210, 212, 214, 216** of the integrated display **100** of the invention.

[0133] Enhanced "T" Instrumentation

[0134] The enhanced "T" instrumentation information includes by example and without limitation: barometric and radio altitude instrumentation information; vertical speed instrumentation information; air speed instrumentation information; navigation instrumentation information including GPS altitude, course, heading, latitude and longitude instrumentation information; autopilot instrumentation information; radio glideslope instrumentation information; flap and gear position instrumentation information; localizer receiver instrumentation information; and radio communication instrumentation information.

[0135] These signals are available to the processor **306** via the data bus **302** and are used as inputs to an algorithm operated by the processor **306** for generating the enhanced "T" instrumentation information displays on the cockpit display **100** or another suitable cockpit display. Accordingly, additional machine instructions stored in the memory **304** are retrieved and operated by the processor **306** for enabling a plurality of the enhanced "T" instrumentation information displays of the invention, including one or more of the altitude instrumentation information display **128**; the pictographic mode information display **134** including the vertical speed instrumentation information display with the pointer **136**; the air speed instrumentation information display **120**; and optionally one or more of a plurality of instrumentation information display that are not shown, including but not limited to radio communications and navigation instrumentation information display portion having navigation instrumentation information displays of one or more of GPS

altitude, course, heading, latitude and longitude instrumentation information; an autopilot instrumentation information display; a radio glideslope instrumentation information display; a flap and a gear position instrumentation information display; and a localizer receiver instrumentation information display.

[0136] A plurality of machine instructions stored in the onboard memory **304**, which are retrieved and operated by a processor **306** to generate the enhanced "T" instrumentation information displays. The machine instructions drive the processor **306** to access a plurality of signals available on the data bus **302** including by example and without limitation: the barometric and radio altitude signals; the vertical speed signal; the air speed signal; the navigation signals including one or more of the GPS altitude, the course, the heading, the latitude and the longitude signals; the autopilot signals; the radio glideslope signal; the flap and gear position signals; the localizer receiver signals; and the radio communication signals. These signals are applied to the processor **306** for generating some or all of the enhanced "T" instrumentation information displays.

[0137] The machine instructions drive the processor **306** to operate an algorithm for determining a current mode or phase of flight as a function of the several instrument information signals available on the data bus **302** that are indicative of different flight parameters. The machine instructions further drive the processor **306** to operate an algorithm for dynamically emphasizing one or more of the different information displays as a function of the current mode or phase of flight by metamorphosis or transformation in appearance using any of animated size, font, shading and texture, as discussed herein.

[0138] Simulated Visual Glideslope Indicator

[0139] In addition to the instrumentation information displays described above, the enhanced "T" instrumentation information displays include the simulated visual glideslope indicator display **148**, also known by the sobriquet "Virtual VASI," which is exemplified in **FIG. 3** and described more completely in co-pending U.S. patent application Ser. No. 10/052,716, entitled SIMULATED VISUAL GLIDESLOPE INDICATOR ON AIRCRAFT DISPLAY, which is incorporated herein by reference. Accordingly, various signals are provided to the integrated display presentation system **300** of the invention for generating and displaying the simulated visual glideslope indicator display **148**. For example, either an aircraft data bus **302** or another suitable means for providing real-time electronic signal data provides the various signals to the processor **306** for generating and displaying the simulated visual glideslope indicator display **148**. These signals are used as inputs to a simulated glideslope circuit or algorithm operated by the processor **306**, which generates a simulated visual glideslope signal whenever the various flight parameters indicate that the aircraft is on an approach. The simulated visual glideslope signal is applied to the display generator **330**, that in turn generates a simulated visual glideslope indicator signal that results in simulated visual glideslope indicator display **148** being presented on the integrated display **100** illustrated in **FIG. 3**.

[0140] For example, the simulated visual glideslope circuit or algorithm receives a plurality of machine instructions stored in the onboard memory **304**, which are retrieved and operated by a processor **306** to generate the simulated glideslope indicator display **148**. The navigation system signal **308** provides current information about the altitude, course, heading, latitude and longitude of the aircraft. The navigation data may be obtained directly from the navigation system, which may include an inertial navigation system, a satellite navigation receiver such as a GPS receiver, VLF/OMEGA, Loran C, VOR/DME or DME/DME, or from a flight management system (FMS).

[0141] Information about the barometric altitude of the aircraft and the vertical speed of the aircraft are available from the navigation system **308**, from an air data computer **310**, or from a barometric altimeter and a barometric rate circuit present on the aircraft. The vertical speed may be expressed as a barometric rate, or as Z velocity, which may be obtained from an onboard inertial navigation system. Alternatively, the processor **306** utilizes altitude signals from a radio altimeter **312**. The altitude signals are optionally geometric altitude signals generated by the computer processor **306**, as described briefly herein and in U.S. Pat. No. 6,216,064, which is incorporated by reference herein. The computer processor **306** includes inputs to receive sources of altitude information.

[0142] The processor **306** may receive a signal from a glideslope receiver **314** to determine whether an ILS is available to provide a glideslope radio signal. The processor **306** may receive discrete signals from discretes **316** and **318** to determine the position of the flaps and landing gear, which indicate whether the aircraft is configured for landing. The processor **306** may also receive signals from a localizer receiver **320** to determine whether the aircraft is on the correct course for a landing.

[0143] The signals from the glideslope receiver **314**, and the flap and landing gear discretes **316** and **318** are applied to the processor **306** for enabling the simulated visual glideslope indicator display **148**. When a request for the simulated visual glideslope indicator display **148** is received by the processor **306**, the signals from the glideslope receiver **314**, and the flap and landing gear discretes **316** and **318** may be interrogated by the processor **306** to determine whether an ILS system is available at the target runway and whether the aircraft is configured for landing. The signals from the localizer receiver **320** may be interrogated by the processor **306** to determine whether the aircraft is aligned with the runway. Such information signals are optionally used by the processor **306** to disable the simulated visual glideslope indicator display **148**.

[0144] The request stimulates the simulated visual glideslope indicator generator operated by the processor **306** to request airport and runway information from the location search logic circuit **328**. The location search logic **328** uses either the latitude and longitude data supplied by the navigation system **308** (shown) or information from the flight plan stored in the onboard FMS to access a database of airport and runway information stored in an onboard memory **326**.

[0145] The request also stimulates the processor **306** to operate the algorithm for generating the simulated visual glideslope indicator display **148**, including the glideslope target **148*a*** and the needle or pointer **148*b***, illustrated in **FIG. 3**. Using the altitude, latitude and longitude data supplied by the navigation system **308**, the glideslope generator circuit or algorithm is operated by the processor **306**

to determine a physical relationship of the aircraft to the target runway. The current relationship is compared with either a stored set of relationship data or with subsequent relationship data to compute an accurate speed over the ground, a vertical speed, a course and a heading, unless these information are otherwise available, e.g., from the air data computer **310** and navigation system **308**. The glideslope generator either computes an acceptable glideslope to the target runway that includes acceptable deviations from an ideal or preferred glideslope, or retrieves a predetermined glideslope from the database **334** of runway and airport information stored in the memory **326** via the search logic **328** as a function of the position of the aircraft as supplied by the navigation system **308**. The computed or retrieved glideslope may optionally include modifications for local obstacles to flight and elevated terrain that affect the approach to the airport, if such information are available.

[0146] The glideslope generator compares the computed relationship of the aircraft to the target runway with the computed ideal or preferred glideslope to determine coincidence and computes the degree and direction of any deviation from the ideal or preferred glideslope. The comparison is used by the processor **306** to generate display control signals that indicate the coincidence or the degree and direction of deviation from the ideal or preferred glideslope. The display control signals are output to the display generator **330** that interprets the display control signal to generate the simulated visual glideslope indicator display **148** on the display **100** in a fashion that mimics a VASI or PAPI system or another airport lighting aid appropriate for the target runway. Thus, the display generator **330** interprets the display control signal to generate a pattern of indicators **148** on the display **100** such that, when the aircraft is on the computed glideslope, black or red colored indicators are illuminated over white colored indicators. Above the computed glideslope, white colored indicators are illuminated over other white colored indicators, and below the computed glideslope black or red colored indicators are illuminated over other black or red colored indicators.

[0147] Furthermore, the display generator **330** interprets the display control signal to generate a scalar color transition between visible indicators **148** such that, as illustrated in **FIG. 3**, the second indicator from the bottom is colored gray or pink (shown shaded) to indicate the slightly below path condition. Similarly, a slightly above path condition could be indicated by showing the second indicator from the top being shaded gray or pink.

[0148] Additionally, the display generator **330** interprets the display control signal to generate the visual glideslope target **148*a*** between the upper and lower visible indicators **148** such that, as illustrated in, the target **148*a*** provides a visual target for the pilot to acquire and maintain during approach.

[0149] The display generator **330** also interprets the display control signal to generate the needle pointer **148*b*** for simulating a traditional vertical deviation scale. The simulated visual glideslope indicator needle **148*b*** indicates the vertical position of the aircraft relative to the ideal or preferred glideslope, and thereby provides additional visual information as to the degree of deviation from the computed ideal or preferred glideslope.

[0150] The display generator **330** also optionally interprets the display control signal to generate the simulated visual glideslope indicator display **148** as a conformal display such that the indicators of the display **148** are presented approximately at the position where ground-based VASI, if available, would be visible from the cockpit.

[0151] The processor **306** is optionally equipped with minimum confidence thresholds for the position and altitude data such that the simulated visual glideslope indicator display **148** may be disabled when the available information is insufficient to calculate a valid approach glideslope.

[0152] The processor **306** optionally receives the glideslope receiver signal **314** and operates machine instructions to disable the simulated visual glideslope indicator display **148** to avoid correlation problems when a ground-based runway visual aid is available.

[0153] Pictographic Mode Awareness Display

[0154] The enhanced "T" instrumentation information displays additionally include the pictographic information display **134**, which is exemplified in **FIG. 3** and described more completely in co-pending U.S. patent application Ser. No. ______ (Attorney Docket No. H0001712), entitled PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT, which is incorporated herein by reference. Accordingly, various signals are provided to the integrated display presentation system **300** of the invention for generating and displaying the pictographic information display **134**. For example, either an aircraft data bus **302** or another suitable means for providing real-time electronic signal data provides the various signals to the processor **306** for generating and displaying the pictographic information display **134**. These signals are used as inputs to a pictographic information display circuit or algorithm operated by the processor **306**, which generates a pictographic information display control signal as a function of various flight parameters that indicate the aircraft's current and next mode of flight. The pictographic information display control signal is applied to the display generator **330**, that in turn generates a pictographic information display control signal that results in the pictographic information display **134** being presented on the display **100** illustrated in **FIG. 3**.

[0155] Machine instructions stored in the memory **304** are retrieved and operated by the processor **306** for enabling the pictographic information display **134**, whereby the pictographic information display **134** is presented on the display **100** having first and second coexisting adjacent areas **222**, **224** including respective visual alphanumeric current mode enunciator and optionally one of currently non-operational or next mode enunciators as disclosed in U.S. patent application entitled PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT. Additional machine instructions stored in the memory **304** are retrieved and operated by the processor **306** for enabling the pictographic information display **134** to present one or both of the directional mode enunciator and an alphanumeric vertical speed enunciator.

[0156] The machine instructions operated by the processor **306** for enabling the pictographic information display **134** include instructions operable by the processor **306** for determining current and armed operational modes of the navigation and autopilot systems, as well as current vertical speed value and slope and generate a control signal informing a pictographical representation symbolic of the current and armed modes of operation, and the current value and slope of vertical speed.

[0157] The machine instructions include instructions operable by the processor 306 for receiving a signal representative of a current mode of operation of one or more instrument systems, such as navigation and autopilot instrument systems; instructions for determining a current mode of operation of the instrument system from the current mode of operation information; and instructions for generating and outputting a display control signal informing a pictographical representation symbolic of the current mode of operation.

[0158] Computer Program Product

[0159] In addition to being practiced as apparatus and methods, the present invention is also practiced as a computer program product for generating and displaying the integrated display presentation of the invention, including the spatial flow symbology, the conformal symbology, and the enhanced "T" instrument information on the cockpit display 100 shown in **FIG. 3** or another suitable cockpit display device. The computer program product of the invention includes a computer-readable storage medium having computer-readable program code means embodied in the medium. With reference to **FIG. 5**, the computer-readable storage medium may be part of the memory device 304, and the processor 306 of the present invention implements the computer-readable program code means for receiving sources of instrument signals reporting flight parameter information and generating a plurality of display control signals informing one or more of the spatial flow symbology presentation, the conformal symbology presentation, and the enhanced "T" instrument information presentation. The different computer-readable program code means for receiving sources of instrument signals reporting flight parameter information and for generating different ones of the plurality of display control signals are optionally present and operated individually or in combination with one or more of the other computer-readable program code means of the present invention.

[0160] Spatial Flow

[0161] The computer-readable program code means includes a first computer-readable program code means for receiving one or more of a source of instrument signals reporting a plurality of flight parameter information; at least a second computer-readable program code means for generating one or more of a plurality of spatial flow symbology display control signals, a plurality of conformal symbology display control signals, and a plurality of enhanced "T" instrument information display control signals. When the second computer-readable program code means is computer-readable program code means for generating one of a plurality of spatial flow symbology display control signals, the second computer-readable program code means are configured as computer-readable program code means for recreating one or more immergent features in the cockpit display 100, the possible immergent features including without limitation: texture, perspective, and color. Thus, when the second computer-readable program code means is computer-readable program code means for generating one of a plurality of spatial flow symbology display control signals, the computer-readable program code means includes a third computer-readable program code means for receiving an altitude data signal and fourth computer-readable program code means for generating an expanded FOV display control signal, including a horizon signal informing the display of the horizon 107 illustrated in **FIG. 3**. Optionally, fifth computer-readable program code means may be included for generating coloration display control signals for applying coloration to either or both the sky 102 and ground 104 portions of the display 100 when the display 100 is a color display. Optionally, sixth computer-readable program code means may be included for generating shading display control signals for applying shading to either or both the sky 102 and ground 104 portions of the display 100 when the display 100 is a either a color display or a two-color display such as a black-and-white display.

[0162] Additionally, seventh computer-readable program code means may be included for generating perspective display control signals informing one or both of horizontal and longitudinal perspective lines, such that horizontal and longitudinal perspective lines 106 are superimposed on the ground 104 with the longitudinal perspective lines 106 converging toward a common vanishing point on or near the horizon 107.

[0163] Additionally, eighth computer-readable program code means may be included for generating texture display control signals for applying texturing on the ground 104 portion of the display. The eighth computer-readable program code means for generating texture display control signals may include computer-readable program code means for generating texture display control signals representative of random texture. The eighth computer-readable program code means for generating random texture display control signals may include computer-readable program code means for accessing instrument data signals representative of motion over the ground, e.g., navigation or air speed signals, determining either indicated or true air speed, and computer-readable program code means for generating random texture display control signals moving across the display as a function of the determined indicated or true air speed.

[0164] Alternatively, the eighth computer-readable program code means for generating texture display control signals may include computer-readable program code means for accessing navigation data signals, determining a substantially real time position of the aircraft, accessing a database 332 of actual ground texture as a function of position, and generating texture display control signals representative of actual ground texture. The eighth computer-readable program code means for generating texture display control signals representative of actual ground texture further include computer-readable program code means for updating the position information by regular sampling of the navigation data signals and generating the texture display control signals as a function of the updated position information.

[0165] Conformal Symbology

[0166] When the second computer-readable program code means is computer-readable program code means for generating of a plurality of conformal symbology display control signals, the second computer-readable program code means includes computer-readable program code means for rendering the conformal symbology using one or both of true one-to-one mapping, or conformal compressed symbology in which the information is rendered using mapping that is not a true one-to-one mapping whereby the information on the display is maximized, as discussed herein. The second

computer-readable program code means for rendering the conformal symbology includes computer-readable program code means for generating one or more simulated aerial traffic cues and terrain object cues for presentation on the cockpit display **100**, the simulated terrain object cues including without limitation: the barometric and radio altitude instrumentation information; the vertical speed instrumentation information; the air speed instrumentation information; the navigation instrumentation information including GPS altitude, course, heading, latitude and longitude instrumentation information; the autopilot instrumentation information; the radio glideslope instrumentation information; the flap and gear position instrumentation information; the localizer receiver instrumentation information; and the aerial traffic detection and collision avoidance information.

[0167] Thus, when the second computer-readable program code means is computer-readable program code means for generating one of a plurality of conformal symbology display control signals, the second computer-readable program code means includes a third computer-readable program code means for receiving altitude, position, course and heading signals and fourth computer-readable program code means for generating display control signals informing one or both of the conformal lateral deviation indicator and lateral path indicator cues **112**, **114** relative to the aircraft's current position and the desired course along the ground. Optionally, when the fourth computer-readable program code means is computer-readable program code means for generating display control signals informing the conformal lateral deviation indicator cues **112** as trapezoids, the fourth computer-readable program code means further includes computer-readable program code means for varying the scaling or distance between the conformal lateral deviation indicator trapezoids **112** as a function of the aircraft's determined altitude above ground, the fourth computer-readable program code means further includes computer-readable program code means for varying the scaling or distance between the conformal lateral deviation indicator trapezoids **112** further including computer-readable program code means for updating the altitude information by regular sampling of the navigation data signals and varying the scaling as a function of the updated altitude information.

[0168] The second computer-readable program code means for generating one or more of a plurality of plurality of conformal symbology display control signals optionally includes the third computer-readable program code means for receiving altitude, position, and course signals, as well as FMS data signals informing the positions of the current and next waypoints. Fourth computer-readable program code means are included for locating one or both of the current and next waypoints relative to the aircraft's current position and course and generating display control signals for locating one or more of the conformal visual landmarks on or near the horizon **107** relative to the aircraft's current position and course. The visual landmarks are optionally the conformal lateral current and next waypoint cues **116**, **118** described herein.

[0169] The fourth computer-readable program code means for locating and generating one or both of the current and next waypoints further includes computer-readable program code means for updating the relative position information by regular sampling of the navigation data signals and generating the display control signals for the conformal lateral current and next waypoint cues **116**, **118** as a function of the updated position information.

[0170] The second computer-readable program code means for generating one or more of a plurality of plurality of conformal symbology display control signals may include third computer-readable program code means for receiving discrete pitch indicator signals **319**. Fourth computer-readable program code means are included for generating display control signal locating the PLI **138** conformally on or near on the center of the display **100** as a function oft the aircraft's current pitch attitude. The fourth computer-readable program code means for generating display control signal locating the conformal PLI **138** further includes computer-readable program code means for updating the pitch attitude information by regular sampling of the pitch indicator data signals **319** and generating the display control signals for the conformal PLI **138** as a function of the updated pitch attitude information.

[0171] The second computer-readable program code means for generating one or more of a plurality of plurality of conformal symbology display control signals and including the third computer-readable program code means for receiving discrete pitch indicator signals **319** may include in the alternative or in combination with the computer-readable program code means for generating display control signal locating the conformal PLI (pitch limit indicator) **138**, computer-readable program code means for generating display control signal locating the conformal pitch tape or pitch scale **140** and horizon **107** as a function oft the aircraft's current pitch attitude. The fourth computer-readable program code means for generating display control signal locating the conformal pitch scale **140** further includes computer-readable program code means for updating the pitch attitude information by regular sampling of the pitch indicator data signals **319** and generating the display control signals for the conformal pitch scale **140** as a function of the updated pitch attitude information.

[0172] The second computer-readable program code means for generating one or more of a plurality of plurality of conformal symbology display control signals optionally includes the third computer-readable program code means for receiving altitude, position, course and heading signals. Fourth computer-readable program code means are included for accessing the database **334** of airport and runway information stored in the onboard memory **326** as a function of the position information. The fourth computer-readable program code means for accessing the database **334** of airport and runway information may optionally include accessing the database **334** as a function of the course or heading information, as in the case of multiple airports in the vicinity.

[0173] Additional computer-readable program code means are included for determining the positions of one or both of the airport and runway relative to the aircraft's current position and heading, and generating display control signals for conformally locating one or both of the airport and runway symbols **110** superimposed on the ground portion **104** of the display relative to the aircraft's current position and heading.

[0174] The computer-readable program code means for positioning and generating one or both of the airport and runway symbols **110** further includes computer-readable program code means for updating the relative position

information by regular sampling of the navigation data signals and generating the display control signals for the conformal airport and runway cues **110** as a function of the updated position information.

[0175] Optionally, the computer-readable program code means for positioning and generating one or both of the airport and runway also includes computer-readable program code means for updating the altitude information by regular sampling of the altitude data signals and varying the scaling of the conformal airport and runway cues **110** as a function of the aircraft's determined altitude above ground. The optional computer-readable program code means further includes computer-readable program code means for generating the display control signal informing the airport portion of the symbol **110** as a function of the altitude signal, e.g., when the aircraft is above about 1,000 feet AGL (above ground level).

[0176] These optional computer-readable program code means further include computer-readable program code means for generating the display control signal informing the runway portion of the symbol **110** while stopping generation of the airport portion of the display control signal as a function of the altitude signal, such that the runway portion of the symbol **110** is presented as the aircraft approaches the ground while the airport portion is removed.

[0177] Furthermore, according to the present invention, any one or more of the plurality of different computer-readable program code means for generating the different conformal symbology display control signals, including the conformal lateral deviation indicator cues **112**, the conformal lateral path indication cues **114**, conformal visual landmarks such as the conformal lateral current and next waypoint cues **116**, **118**, the conformal PLI (pitch limit indicator) cue **138**, the conformal pitch scale cue **140**, and the conformal runway/airport symbol **110**, is optionally operated independently or in combination with any one or more of the other plurality of different computer-readable program code means for generating the different conformal symbology display control signals. Thus, the different conformal symbology displays can be presented on the display independently or in any combination with the other conformal symbology displays.

[0178] Optionally, the computer-readable program code means for retrieving and displaying in a wide-angle look-ahead mode intruder aircraft and collision avoidance information supplied by a TCAS (Traffic Alert Collision Avoidance System) or ACAS (Airborne Collision Avoidance System) or another aerial traffic detection and collision avoidance system. The TCAS repeater computer-readable program code means thus includes computer-readable program code means for retrieving all aerial traffic detection and collision avoidance information from the onboard TCAS equipment, or for retrieving at least a portion of the aerial traffic detection and collision avoidance information that is relevant to a current FOV presented by the display **100** of the invention. As discussed herein, the computer-readable program code means for rendering the conformal TCAS symbology utilizes either true one-to-one mapping, or conformal compressed symbology in which the information is rendered using mapping that is not a true one-to-one mapping whereby the information on the display is maximized. When the TCAS repeater computer-readable program code means includes computer-readable program code means for retrieving all aerial traffic detection and collision avoidance information from the onboard TCAS equipment, additional computer-readable program code means are included for isolating that portion of the information that lies within the scope of the illustration of the real world provided on the display **100**, i.e., the FOV of the display **100**. Additionally, the TCAS repeater computer-readable program code means includes computer-readable program code means for converting the 3-dimensional traffic data received from the TCAS equipment into a 2-dimensional wide-angle look-ahead view. Also included are computer-readable program code means for presenting the aerial traffic detection and collision avoidance information relevant to the current FOV of the display **110** conformally superimposed with the sky and ground portions **102**, **104**, shown in **FIG. 3**. The TCAS repeater computer-readable program code means thus causes the intruder aircraft to appear on the display **100** at approximately the same positions relative to the aircraft as they would appear, if visible, through the cockpit windscreen. Furthermore, the computer-readable program code means for presenting the aerial traffic detection and collision avoidance information on the display **110** include computer-readable program code means for using conventional TCAS horizontal display symbology and processes for depicting the intruding aircraft as discussed herein, thereby maximizing commonality with conventional TCAS navigation displays.

[0179] The TCAS repeater computer-readable program code means further includes computer-readable program code means for displaying conventional TCAS threat level indicators, the threat level of each intruder aircraft within the FOV presented by the display **100** being repeated in combination with the corresponding indicia or tag **202**, **204**, **206** that represents the intruder.

[0180] Computer-readable program code means are included for using conventional TCAS symbology to represent the relative altitude difference between the protected host aircraft and the intruder aircraft; whether the intruder is above or below the host aircraft; the two digit number that provides a visual cue as to the intruder aircraft's relative position; and the vertical arrow indicator of the intruder's altitude rate of change.

[0181] Furthermore, computer-readable program code means are included for regularly updating the relative position of the aerial traffic detection and collision avoidance information as a function of the protected host aircraft's real time position, heading and altitude.

[0182] When the protected host aircraft is provided with the improved four-antenna TCAS system as taught by U.S. Pat. No. 4,855,748, the TCAS repeater computer-readable program code means further includes computer-readable program code means for utilizing knowledge of the relative bearing of the intruding aircraft from the protected aircraft, in addition to the other data normally collected by standard TCAS equipment, to provide advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers. Additional computer-readable program code means are included for repeating the TCAS advisories for horizontal right or left turn maneuvers as well as for vertical maneuvers.

[0183] Other computer-readable program code means are included for repeating the TCAS text displays wherein

conditions of the TCAS are reported. The computer-readable program code means for repeating TCAS text displays being computer-readable program code means for repeating TCAS text displays in one or more of the areas represented by rectangular boxes **208, 210, 212, 214, 216** of the integrated display **100** of the invention.

[0184] Enhanced "T" Instrumentation

[0185] When the second computer-readable program code means is computer-readable program code means for generating of a plurality of the enhanced "T" instrument information presentation displays as one or more display control signals, the second computer-readable program code means for generating one or more of enhanced "T" instrument information displays for presentation on the cockpit display **100**, the instrument information displays including without limitation: barometric and radio altitude instrumentation information displays; vertical speed instrumentation information displays; air speed instrumentation information displays; navigation instrumentation information displays including GPS altitude, course, heading, latitude and longitude instrumentation information displays; autopilot instrumentation information displays; radio glideslope instrumentation information displays; flap and gear position instrumentation information displays; and localizer receiver instrumentation information displays.

[0186] Thus, when the second computer-readable program code means is computer-readable program code means for generating one of the plurality of enhanced "T" instrument information display control signals, the second computer-readable program code means includes third computer-readable program code means for receiving barometric and radio altitude data signals; vertical speed data signals; air speed data signals; navigation data signals including GPS altitude, course, heading, latitude and longitude data signals; autopilot data signals; radio glideslope data signal; flap and gear position data signals; pitch attitude data signals; and localizer receiver data signals. The second computer-readable program code means further includes fourth computer-readable program code means for generating display control signals informing one or more instrument information display control signals, including one or more of an altitude display control signal; a vertical speed display control signal; an air speed display control signal; a navigation display control signal including one or more of GPS altitude, course, heading, latitude and longitude display control signals; autopilot display control signals; radio glideslope display control signals; flap and gear position display control signals; pitch attitude display control signals; and localizer receiver display control signals.

[0187] The fourth computer-readable program code means for generating one or more of the different display control signals further includes computer-readable program code means for dynamically emphasizing one or more of the different information displays by informing the one or more different information display control signal with a metamorphosis or transformation in appearance as a function of the current mode or phase of flight. The metamorphosis or transformation in appearance being any one or more of an animated size, font, shading and texture, as discussed herein.

[0188] The fourth computer-readable program code means for generating one or more of the different display control signals further includes computer-readable program code means for updating the instrument information by regular sampling of the different instrument data signals and varying the different instrument display control signals as a function of the updated instrument information.

[0189] Simulated Visual Glideslope Indicator

[0190] With reference to the computer-readable program code means for generating radio glideslope instrumentation information displays **148**, the computer-readable program code means include computer-readable program code means for determining deviation from an ideal or preferred glideslope and generating a signal representative of the amount or degree of deviation.

[0191] The computer-readable program code means thus include computer-readable program code means for determining a global position from a received plurality of navigation data signals; computer-readable program code means for determining an altitude above ground level from one or more received navigation datum; computer-readable program code means for retrieving a plurality of airport information from the database **334** of airport information as a function of the predetermined aircraft position information; computer-readable program code means for determining coincidence between the predetermined aircraft position information combined with the predetermined aircraft altitude information and an ideal or preferred glideslope determined as a function of the predetermined airport information; and computer-readable program code means for generating and outputting an instrument information display control signal as a function of the predetermined coincidence between the predetermined aircraft position and altitude information and the ideal or preferred glideslope.

[0192] The computer-readable program code means for determining coincidence between the predetermined aircraft position and altitude information and the ideal or preferred glideslope may include means for computing the ideal or preferred glideslope as a function of the airport information. Alternatively, the computer-readable program code means for determining the coincidence may include computer-readable program code means for retrieving the glideslope as one of the plurality of airport information retrieved from the database **334** of airport information stored in the memory **326**.

[0193] As discussed previously, the computer program product further includes computer-readable program code means for interpreting the instrument information display control signal output by the signal generating means as the simulated visual glideslope indicator display **148** embodied as a pattern of illuminated indicators on a cockpit display such as the display **100**. For example, the computer-readable program code means may interpret the signal output by the fifth computer-readable program code means as a pattern of illuminated indicators that simulate on a cockpit display a known airport lighting aid, such as one of a simulated VASI or PAPI airport lighting aid or another standard airport lighting aid. The computer-readable program code means may further interpret the display control signal as a pattern of monochromatic or colored indicators that is presented on the display substantially conformally with the ground as viewed from the cockpit of the host aircraft.

[0194] Optionally, the computer-readable program code means may additionally interpret the display control signal

as a needle or pointer indicator **148b** for simulating on the display the traditional vertical deviation scale, and thereby provide additional information as to the degree of coincidence or deviation.

[0195] Pictographic Mode Awareness Display

[0196] With reference to the computer-readable program code means for generating the pictographic instrument information displays **134**, the computer-readable program code means include computer-readable program code means for determining current and armed operational modes of the navigation and autopilot systems, as well as current vertical speed value and slope, and for generating a display control signal informing a pictographical representation symbolic of the current and armed modes of operation, and the current value and slope of vertical speed. The computer-readable program code means thus include computer-readable program code means enunciating current and armed operational modes of the navigation and autopilot systems, as well as current vertical speed value and slope. determine.

[0197] As described in U.S. patent application entitled PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT, which is incorporated herein by reference, and outlined briefly here, the computer-readable program code means for generating the pictographic instrument information displays **134** include computer-readable program code means for receiving a signal representative of a current mode of operation of one or more instrument systems, such as navigation and autopilot instrument systems; computer-readable program code means for determining a current mode of operation of the instrument system from the current mode of operation signal; and computer-readable program code means for generating and outputting a display control signal informing a pictographical representation symbolic of the current mode of operation.

[0198] Additional computer-readable program code means may include for either simultaneously or subsequently receiving the signal representative of a current vertical speed of the aircraft. The computer-readable program code means may also include computer-readable program code means for generating and outputting a display control signal informing an alphanumeric representation of the value of the current vertical speed in combination with the display control signal informing a pictographical representation symbolic of the current mode of operation.

[0199] The computer-readable program code means for generating the pictographic instrument information displays **134** include computer-readable program code means for receiving other aircraft information signals and for generating and outputting display control signals as described more fully in U.S. patent application for PICTOGRAPHIC MODE AWARENESS DISPLAY FOR AIRCRAFT.

[0200] While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A display control device, comprising:

a processor structured for receiving samples of one or more signals reporting one or more different flight parameter data; and

one or more algorithms resident on the processor for generating as a function of the flight parameter information one or more display control signals for causing a display device to display one of a spatial flow symbology presentation, a conformal symbology presentation, and a plurality of instrument information presentations each having a dynamic transformation in appearance as a function of the flight parameter data.

2. The device of claim 1, further comprising a display generator coupled for receiving from the processor the display control signal and being structured for interpreting the display control signal to generate the spatial flow symbology, conformal symbology, and enhanced "T" instrument information presentations on the display.

3. The device of claim 1 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display a field of view presenting a wide-angle view of an upper sky portion separated by a horizon line from a lower ground portion.

4. The device of claim 3 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display one or more of texture, perspective, and color display features.

5. The device of claim 4 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display color features in one or both of the sky portion and the ground portion of the display presentation.

6. The device of claim 4 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display a graduated shading of one or both of the sky portion and the ground portion of the display presentation.

7. The device of claim 4 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display a plurality of perspective lines over the ground portion of the display presentation.

8. The device of claim 7 wherein the one or more algorithms for generating the spatial flow symbology presentation further comprise one or more algorithms for generating one or more display control signals for causing a display device to display one or more texture cues on the ground portion of the display presentation.

9. The device of claim 1 wherein the one or more algorithms for generating the conformal symbology presentation further comprises one or more algorithms for generating, as a function of navigation information, one or more display control signals for causing a display device to display one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol in combination with a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and conformal aerial traffic detection and collision avoidance symbols.

10. The device of claim 1 wherein the one or more algorithms for generating the plurality of instrument information presentations further comprise one or more algorithms for generating one or more dynamically emphasized flight parameter data indicator, the flight parameter data indicator being dynamically emphasized as a function of the flight parameter data.

11. The device of claim 10 wherein the one or more algorithms for generating one or more dynamically emphasized flight parameter data indicators further comprises one or more algorithms for dynamically generating the emphasized flight parameter data indicator having one or more of an enhanced size, font, shading and texture.

12. A display control device, comprising:

a processor coupled for receiving at a known sampling rate one or more different instrument data signals each reporting information about one or more different flight parameters; and

one or more algorithms resident on the processor and executable by the processor, the algorithms being structured to generate a plurality of display control signals as a function of the flight parameter information, the display control signals being structured to cause a display device to display one or more of:

graphical depictions symbolic of one or more of a plurality of spatial motion and energy cues of a type available in flying Visual Flight Rules,

navigation information as graphical depictions symbolic of one or more of a plurality of ground-based phenomena conformally as a function of the navigation information, and

a plurality of graphical depictions symbolic of the different instrument data, one or more of the plurality of graphical depictions being dynamically emphasized as a function of one of the different flight parameters.

13. The display control device of claim 12 wherein the one or more algorithms resident on and executable by the processor are structured to generate display control signals that cause a display device to display the graphical depictions of one or more of the spatial motion and energy cues, one or more of the ground-based phenomena, and one or more of the different instrument data.

14. The display control device of claim 13 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display a wide-angle look-ahead field of view (FOV), the FOV having a sky portion and a ground portion separated by a horizon representation and being superimposed with one or more of texture, perspective, and color features.

15. The display control device of claim 14 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display graded color features superimposed on one or both of the sky portion and the ground portion of the FOV

16. The display control device of claim 14 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display perspective lines superimposed on the ground portion of the FOV.

17. The display control device of claim 14 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the spatial motion and energy cues further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display one or more texture cues on the ground portion of the FOV.

18. The display control device of claim 14 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the conformal ground-based phenomena further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display one or more of a conformal runway/airport symbol, conformal lateral deviation indicator lateral path indication symbols, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic symbol.

19. The display control device of claim 14 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the instrument data further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display one or more of an indicated air speed, an attitude, an altitude, a heading, a pictographic mode of flight indicator, a visual glideslope, and a navigation information.

20. The display control device of claim 19 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the graphical depictions of the instrument data further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display one of the graphical depictions of the instrument data as a dynamically emphasized graphical depiction as a function of one of a mode and a phase of flight.

21. The display control device of claim 20 wherein the one or more algorithms that are structured to generate display control signals that cause a display device to display the dynamically emphasized graphical depiction of instrument data further comprise one or more algorithms that are structured to generate display control signals that cause a display device to display the dynamically emphasized graphical depiction of instrument data as having a visual appearance different from a nominal visual appearance.

22. A display control device, comprising:

means for receiving samples of one or more signals reporting flight parameter information; and

means for generating on a display device one of a spatial flow symbology display presentation, a conformal symbology display presentation, and a plurality of instrument information display presentations each having a transformation in appearance as a function of the flight parameter information.

23. The device of claim 22 wherein the means for generating the spatial flow symbology display presentation further comprises means for generating one or more of texture, perspective, and color display features on the display device.

24. The device of claim 23, further comprising means for generating an expanded field of view (FOV) on the display device, the expanded FOV display presenting a wide-angle view of an upper sky portion separated by a horizon line from a lower ground portion.

25. The device of claim 24, further comprising means for generating color features in one or both of the sky portion and the ground portion of the spatial flow symbology display presentation.

26. The device of claim 24, further comprising means for generating a graded shading of one or both of the sky portion and the ground portion of the spatial flow symbology display presentation.

27. The device of claim 24, further comprising means for generating a plurality of perspective lines superimposed over the ground portion of the display presentation.

28. The device of claim 27, further comprising means for generating one or more texture cues on the ground portion of the spatial flow symbology display presentation.

29. The device of claim 22 wherein the means for generating the conformal symbology display presentation further comprises means for generating, as a function of navigation information, one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol and a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic detection and collision avoidance information symbol.

30. The device of claim 22 wherein the means for generating the plurality of instrument information display presentations further comprises means for generating one or more dynamically emphasized flight parameter indicator, the flight parameter indicator being dynamically emphasized as a function of the flight parameter information.

31. The device of claim 30 wherein the means for generating one or more dynamically emphasized flight parameter indicator further comprises means for dynamically generating the emphasized flight parameter indicator having one or more of an enhanced size, font, shading and texture.

32. A display control device, comprising:

a means for receiving at intervals samples of one or more instrument signals reporting updated information about one or more different flight parameters; and

a means for generating on a display device as a function of the updated flight parameter information one or more of:

graphical depictions replicating one or more of a plurality of spatial motion and energy cues of a type available in conventional visual flying,

navigation information as graphical depictions symbolic of one or more of a plurality of ground-based phenomena in positions that conform to a view from a position and altitude consistent with the navigation information, and

a plurality of different instrument information presentations that are dynamically emphasized as a function of one of the different flight parameter information.

33. The display control device of claim 32 wherein the means for generating on a display device one or more of the graphical depictions, the navigation information, and the instrument information presentations further comprises means for generating each of the graphical depictions, the navigation information, and the instrument information presentations.

34. The display control device of claim 33 wherein the means for generating the graphical depictions replicating the spatial motion and energy cues on a display device further comprise means for generating on the display device a field of view (FOV) expanded a first angular degree in the horizontal and a second lesser angular degree in the vertical, the FOV having a sky portion and a ground portion separated by a horizon representation and being superimposed with one or more of texture, perspective, and color features.

35. The display control device of claim 34 wherein the means for generating the graphical depictions replicating the spatial motion and energy cues on a display device further comprise means for generating on the display device graded color features in one or both of the sky portion and the ground portion of the FOV.

36. The display control device of claim 34 wherein the means for generating the graphical depictions replicating the spatial motion and energy cues on a display device further comprise means for generating on the display device perspective lines on the ground portion of the FOV.

37. The display control device of claim 34 wherein the means for generating the graphical depictions replicating the spatial motion and energy cues on a display device further comprise means for generating on the display device one or more texture cues on the ground portion of the FOV.

38. The display control device of claim 34 wherein the means for generating the navigation information on a display device further comprise means for generating on the display device one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol and a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic symbol.

39. The display control device of claim 34 wherein the means for generating the plurality of different instrument information presentations on a display device further comprise means for generating on the display device one or more of a presentation representative of an indicated air speed, a presentation representative of an attitude, a presentation representative of an altitude, a presentation representative of a heading, a pictographic presentation representative of a mode of flight, a presentation representative of a visual glideslope, and a presentation representative of navigation information.

40. The display control device of claim 39 wherein means for generating one or more of a presentations on the display device further comprise means for generating on the display device as a function of a mode or a phase of flight one of the presentations as a dynamically emphasized presentation.

41. The display control device of claim 40 wherein the means for generating one or more of the presentations as a dynamically emphasized presentation further comprise means for generating on the display device the dynamically

emphasized presentation as having a visual appearance different from a nominal visual appearance.

42. An integrated display presentation for tactical flight path management, the integrated display presentation comprising:

a source of a plurality of instrument data signals each reporting flight parameter data;

a memory having a plurality of machine instructions stored therein, the machine instructions being executable by a processor for causing a display device to display one or more of a spatial flow symbology presentation, a conformal symbology presentation, and an instrument information presentation that exhibits a dynamic transformation in appearance as a function of the flight parameter data;

a processor coupled to receive the instrument data signals and coupled to the memory for retrieving the machine instructions, the processor being structured to operate the machine instructions for generating one or more of the spatial flow symbology presentation, the conformal symbology presentation, and the instrument information presentation, wherein:

the spatial flow symbology presentation is generated as a function of speed data,

the conformal symbology presentation is generated as a function of position, altitude and heading data, and

the dynamic transformation of the instrument information presentation is generated as a function of a mode or phase of flight data; and

a cockpit display being coupled to receive and display the spatial flow symbology, conformal symbology, and instrument information presentations.

43. The generator of claim 42 wherein the machine instructions for generating the spatial flow symbology presentation further comprise machine instructions for generating an expanded field of view having sky and ground portions, and including one or more of color, perspective and texture display features applied to one or both of the sky and ground portions for replicating a plurality of spatial motion and energy cues.

44. The generator of claim 43 wherein the machine instructions for generating the color display features further comprise machine instructions for generating a gradation in intensity of color in one or both of the sky and ground portions, the intensity generally decreasing with distance from an intersection of the sky and ground portions.

45. The generator of claim 43 wherein the machine instructions for generating the perspective display features further comprise machine instructions for generating a plurality of horizontal and longitudinal perspective lines that are superimposed on the ground portion, with the longitudinal perspective lines converging to a common vanishing point near an intersection of the sky and ground portions.

46. The generator of claim 42 wherein the machine instructions for generating the conformal symbology presentation further comprise machine instructions for generating one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol in combination with a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic detection and collision avoidance information symbol.

47. The generator of claim 42 wherein the machine instructions for generating the dynamic transformation of the instrument information presentation further comprise machine instructions for generating a dynamic transformation of one or more of a size, font, shading and texture of the instrument information presentation.

48. The generator of claim 42 wherein the machine instructions for generating the dynamic transformation of the instrument information presentation further comprise machine instructions for generating a glideslope, comparing position and altitude data to the glideslope, and generating a signal representative of deviation of the position and altitude data from the glideslope.

49. The generator of claim 42 wherein the machine instructions for generating the dynamic transformation of the instrument information presentation further comprise machine instructions for generating a pictographic enunciator symbolizing a current operational state of an onboard instrument or instrument system.

50. The generator of claim 42 wherein the source of a plurality of instrument data signals each reporting flight parameter data further comprises a source of aerial traffic detection and collision avoidance information signals; and

wherein the machine instructions for causing a display device to display a conformal symbology presentation further comprises machine instructions executable by a processor for causing a display device to display a conformal symbology presentation of the aerial traffic detection and collision avoidance information signals.

51. A computer program residing on a computer usable storage medium, the computer program comprising:

computer-readable program code means for receiving at intervals one or more signals representative of updated flight parameter information; and

computer-readable program code means for generating and outputting a plurality of display control signals informing one of a spatial flow symbology presentation, a conformal symbology presentation, and a plurality of instrument information presentations each having a metamorphosis in appearance as a function of the updated flight parameter information.

52. The computer program of claim 51 wherein the computer-readable program code means for generating and outputting a plurality of display control signals informing the spatial flow symbology presentation further comprises computer-readable program code means for generating and outputting a plurality of display control signals informing one or more of texture, perspective, and color features.

53. The computer program of claim 52, further comprising computer-readable program code means for generating an expanded field of view (FOV) display control signal, the FOV display control signal informing a wide-angle view of the spatial flow symbology presentation having a sky portion and a ground portion, the sky and ground portions being separated by a horizon representation.

54. The computer program of claim 53, further comprising computer-readable program code means for generating coloration display control signals informing color features in one or both of the sky portion and the ground portion of the spatial flow symbology presentation.

55. The computer program of claim 53, further comprising computer-readable program code means for generating coloration display control signals informing a graded shading of one or both of the sky portion and the ground portion of the spatial flow symbology presentation.

56. The computer program of claim 53, further comprising computer-readable program code means for generating perspective display control signals informing perspective lines on the ground portion of the spatial flow symbology presentation.

57. The computer program of claim 56, further comprising computer-readable program code means for generating texture display control signals informing texture cues on the ground portion of the spatial flow symbology presentation.

58. The computer program of claim 51 wherein the computer-readable program code means for generating and outputting a plurality of display control signals informing the conformal symbology presentation further comprises computer-readable program code means for generating and outputting a plurality of display control signals informing one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol and a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic information symbol.

59. The computer program of claim 51 wherein the computer-readable program code means for generating and outputting a plurality of display control signals informing the plurality of instrument information presentations further comprises computer-readable program code means for generating and outputting a plurality of display control signals informing one or more of an indicated air speed indicator, a ball/attitude indicator, an altitude indicator, a turn coordinator, a heading pointer, a pictographic information display, a simulated visual glideslope information display, and a Traffic Alert Collision Avoidance System (TCAS) navigation information display.

60. The computer program of claim 59 wherein the computer-readable program code means for generating and outputting a plurality of display control signals informing the plurality of instrument information presentations further comprises computer-readable program code means for generating emphasizing display control signals informing emphasis in one of the plurality of instrument information presentations as a function of the updated flight parameter information.

61. The computer program of claim 60 wherein the computer-readable program code means for generating emphasizing display control signals informing emphasis in one of the plurality of instrument information presentations further comprises computer-readable program code means for generating metamorphic display control signals informing a metamorphosis of the instrument information presentation.

62. The computer program of claim 61 wherein the computer-readable program code means for generating metamorphic display control signals informing metamorphosis of the instrument information presentation further comprises computer-readable program code means for generating display control signals informing a metamorphosis of one or more of size, font, shading and texture of the instrument information presentation

63. A computer program product, comprising:

a computer-usable medium having computer-readable code embodied therein for configuring a computer processor, the computer program product comprising:

computer-readable code configured to cause a computer processor to receive at intervals samples of one or more instrument signals reporting updated flight parameter information;

computer-readable code configured to cause a computer processor to generate at intervals and as a function of the updated flight parameter information a plurality of display control signals for causing a display device to display one of:

a spatial flow symbology presentation as a graphical presentation replicating one or more of a plurality of spatial motion and energy cues of a type available in conventional visual flying,

a conformal symbology presentation of navigation information as visual depictions symbolic of one or more of an aerial and a ground-based phenomenon as to conform to a view from a position and altitude consistent with the navigation information, and

a plurality of different enhanced "T" presentations of instrument information, one or more of the presentations of instrument information being dynamically emphasized as a function of the updated flight parameter information; and

computer-readable code configured to cause a computer processor to output the plurality of display control signals.

64. The computer program product of claim 63 wherein the computer-readable code is further configured to cause a computer processor to generate a plurality of display control signals for causing a display device to display each of the spatial flow symbology presentation, the conformal symbology presentation, and the enhanced "T" presentations.

65. The computer program product of claim 64 wherein the plurality of display control signals for causing a display device to display the spatial flow symbology presentation further comprise a plurality of display control signals for causing a display device to display a field of view (FOV) expanded at a wide angle in the horizontal and expanded in the vertical about one half the horizontal angle, and having a sky portion and a ground portion separated by a horizon representation and each being superimposed with one or more of texture, perspective, and color features

66. The computer program product of claim 65 wherein the plurality of display control signals for causing a display device to display the spatial flow symbology presentation further comprise a plurality of display control signals for causing a display device to display graded color features in one or both of the sky portion and the ground portion of the spatial flow symbology presentation.

67. The computer program product of claim 65 wherein the plurality of display control signals for causing a display device to display the spatial flow symbology presentation further comprise a plurality of display control signals for causing a display device to display perspective lines on the ground portion of the spatial flow symbology presentation.

68. The computer program product of claim 65 wherein the plurality of display control signals for causing a display

device to display the spatial flow symbology presentation further comprise a plurality of display control signals for causing a display device to display texture cues on the ground portion of the spatial flow symbology presentation.

69. The computer program product of claim 65 wherein the plurality of display control signals for causing a display device to display the conformal symbology presentation further comprise a plurality of display control signals for causing a display device to display one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol in combination with a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, a conformal next waypoint symbol, and a conformal aerial traffic information symbol.

70. The computer program product of claim 65 wherein the plurality of display control signals for causing a display device to display the plurality of different enhanced "T" presentations further comprise a plurality of display control signals for causing a display device to display one or more of a presentation representative of an indicated air speed, a presentation representative of an attitude, a presentation representative of an altitude, a presentation representative of a heading, a pictographic presentation representative of a mode of flight, a presentation representative of a visual glideslope, and a presentation representative of navigation information.

71. The computer program product of claim 70 wherein the plurality of display control signals for causing a display device to display the plurality of different enhanced "T" presentations further comprise a plurality of display control signals for causing a display device to display as a function of a mode or a phase of flight one of the presentations as a dynamically emphasized presentation.

72. The computer program product of claim 71 wherein the plurality of display control signals for causing a display device to display one or more of the presentations as a dynamically emphasized presentation further comprise a plurality of display control signals for causing a display device to display the presentation as having a visual appearance different from a nominal visual appearance.

73. A method for displaying flight parameter information, the method comprising:

receiving samples of one or more data signals reporting flight parameter information; and

in response to the flight parameter information, presenting on a display device one or more of a spatial flow symbology display, a conformal symbology display, and a plurality of instrument information displays, the appearance of each instrument information display transforming as a function of the flight parameter information.

74. The method of claim 73 wherein presenting the spatial flow symbology display further comprises presenting one or more of texture, perspective, and color display features on the display device.

75. The method of claim 74, further comprising presenting on the display device wide-angle sky and ground portions separated by a horizon line.

76. The method of claim 75, further comprising presenting color features in one or both of the sky portion and the ground portion of the display.

77. The method of claim 75, further comprising presenting a graded shading of one or both of the sky portion and the ground portion of the display.

78. The method of claim 75, further comprising presenting a plurality of perspective lines over the ground portion of the display.

79. The method of claim 78, further comprising presenting one or more texture cues on the ground portion of the display.

80. The method of claim 73 wherein presenting the conformal symbology display further comprises presenting on the display device, as a function of navigation information, one or more of a conformal runway/airport symbol, a conformal lateral deviation indicator symbol and a conformal lateral path indication symbol, a conformal lateral current waypoint symbol, and a conformal next waypoint symbol, and a conformal aerial traffic information symbol.

81. The method of claim 73 wherein presenting the plurality of instrument information displays further comprises presenting one or more dynamically emphasized flight parameter indicators as a function of the flight parameter information.

82. The method of claim 81 wherein presenting one or more dynamically emphasized flight parameter indicators further comprises dynamically enhancing one or more of an enhanced size, font, shading and texture of the flight parameter indicator.

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